THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 9 APRIL, 1945 NUMBER 2

LIFE HISTORY OF THE EASTERN PICKEREL IN BABCOCK POND, CONNECTICUT[1]

Leonard E. Foote and Bradford P. Blake[2]

Vermont Fish and Game Service, Montpelier, Vermont, and University of Connecticut, Storrs, Connecticut

The eastern pickerel (*Esox niger*) is an important game fish throughout its range, but little is known of its life history and ecology. Hunter and Rankin (1939) and Raney (1942) have summarized the food habits of the species, Webster (1942) has written of its life history in Connecticut, and general accounts of its life history have been provided by Adams and Hankinson (1928) and Kendall (1917). This pickerel undoubtedly inhabits all of the larger streams in Connecticut, being present in over 240 of the 270 lakes and ponds stocked with pond fish from 1932 to 1936 (Clark, 1936), and it is ranked as an excellent game fish by sportsmen.

There is still an insufficiency of information concerning the population of any species of game fish in relation to the total area or volume of water inhabited. Two methods are available for estimating the total population under natural conditions. One necessitates either catching or killing the entire population to make an objective count (Smith, 1939). The other involves estimating the total number by the use of the jaw tag or some other means of identifying specimens recaptured, and counting a sample of the population by proportion. The latter method has been used by Lincoln (1930) for obtaining estimates of waterfowl numbers, by Raney (1940) for studies on summer movements of the bullfrog, and by many other workers.

A jaw-tag study of the eastern pickerel was undertaken during the summers of 1940 and 1941 on Babcock Pond which lies in the towns of Colchester and East Haddam, Connecticut, and drains into the Salmon River. This is an artificial pond of 200 acres, maintained by the East Haddam Fish and Game Club which owns or controls the surrounding land. The Club secured control of the pond in 1937, since when no public fishing has been permitted. The shores are well forested and grazed in part by cattle. The lake is of the bog type, containing such plants as water willow, buttonbush, sedges, and ferns, all of which facilitate mat formation. About one-half of the total area is open water and the remainder is covered by floating and emergent vegetation. The bottom is a deposit of partially decomposed organic matter overlying either a mud or gravel substratum. The maximum depth of

[1] This study was made under the direction of N. W. Hosley, University of Connecticut; Leo H. Height, J. T. Linehan, the late Robert T. Thayer, and others aided in the work.

[2] Sergeant Bradford Pethick Blake died of wounds in an English hospital in 1943.

water was estimated at eight feet, the water is dark brown, and visibility is poor. Water temperatures exceed 80°F. during warm periods.

Fishes present were the common bullhead (*Ameiurus n. nebulosus*), golden shiner (*Notemigonus c. crysoleucas*), bridled minnow (*Notropis bifrenatus*), common sunfish (*Lepomis gibbosus*), and eastern pickerel (*Esox niger*). The presence of the common eel (*Anguilla bostoniensis*) and, at some seasons, of the brook trout (*Salvelinus f. fontinalis*), was questionable.

From June to September in 1940 and 1941, pickerel were caught with rod and line; the total length of each measured to the nearest quarter inch, each was tagged with a stainless steel strap tag, serially-numbered and bearing the initials "U. of C.," and then released. The tag was placed in either the operculum or the lower jaw; many fish not tagged were fin-clipped by removal of the anal fin.

Over 200 fish were taken for life-history study, the weights, measurements, and examinations of all being made while fresh. The stomachs were preserved in formalin for later examination. Catch records were kept by individual anglers and included pertinent information on weather, bait, time of fishing, and number of fish caught and removed.

In 1940, 647 fish were caught; of these, 267 were tagged and 114 were fin-clipped. In 1941, 639 additional fish were taken, of which 371 were tagged in the lower jaw. The frequency, by total length, of all fish measured and tagged or taken for life-history study in 1940 and 1941 is shown in Table 1. Of the fish caught in 1940, 66.8 per cent were under the legal length limit of 12 inches, and 62.1 per cent in the 1941 collection.

No significant increase was found in the average total length of fish taken from June to September; the mean size for all measured in 1940 was 11.2 inches, and in 1941 was 11.9 inches. The smallest taken was only 6.25 inches in total length and the largest was 22.25 inches.

Since the methods of fishing probably

TABLE 1.—LENGTH AND TIME OF CAPTURE OF 959 EASTERN PICKEREL FROM BABCOCK POND, EAST HADDAM, CONNECTICUT, 1940–41.

Total length, inches	*1940*				*Totals*		*1941*				*Totals*		*Grand totals*	
	June	*July*	*Aug.*	*Sept.*	*No.*	*Per-centage*	*June*	*July*	*Aug.*	*Sept.*	*No.*	*Per-centage*	*No.*	*Per-centage*
6.0– 6.9	—	—	—	—	—	—	—	—	—	1	1	*0.1*	1	—
7.0– 7.9	1	4	2	2	9	*2.5*	11	5	1	—	17	*2.8*	26	*2.7*
8.0– 8.9	3	7	7	12	29	*8.0*	23	25	4	1	53	*8.8*	82	*8.5*
9.0– 9.9	2	13	17	21	53	*14.9*	41	26	14	—	81	*13.5*	134	*13.9*
10.0–10.9	16	17	20	28	81	*22.5*	53	40	11	10	114	*19.0*	195	*20.3*
11.0–11.9	7	12	22	27	68	*18.9*	56	29	19	4	108	*18.0*	176	*18.3*
MINIMUM LEGAL LENGTH														
12.0–12.9	5	19	19	28	71	*19.7*	39	17	18	1	74	*12.3*	146	*14.2*
13.0–13.9	1	9	3	12	25	*6.9*	24	25	7	2	58	*9.7*	83	*8.5*
14.0–14.9	2	2	6	5	15	*4.1*	13	6	2	3	24	*4.0*	39	*4.1*
15.0–15.9	—	—	2	1	3	*0.8*	9	6	3	1	19	*3.2*	23	*2.4*
16.0–16.9	—	—	—	3	3	*0.8*	7	7	3	1	18	*3.0*	21	*2.3*
17.0–17.9	—	—	1	—	1	*0.3*	4	6	2	—	12	*2.0*	13	*1.3*
18.0–18.9	—	—	—	1	1	*0.3*	1	3	1	—	5	*0.8*	6	*0.6*
19.0–19.9	—	—	—	—	—	—	1	2	2	1	6	*1.0*	6	*0.6*
20.0–20.9	—	—	—	—	—	—	1	3	2	—	6	*1.0*	6	*0.6*
21.0–21.9	—	—	—	—	—	—	—	—	2	—	2	*0.3*	2	*0.2*
22.0–22.9	—	—	—	—	—	—	—	2	—	—	2	*0.3*	2	*0.2*
Totals	37	83	98	139	359		283	202	91	25	600		959	

were selective for the larger size classes, it must be assumed that the following population estimate is valid only for the numbers which could be caught by the same methods; i.e., those from 6 to over 22 inches in length.

Fish tagged in 1940	267
Unmarked fish caught in 1941	669
Tagged fish caught in 1941	14
Fish collected in 1941	683

Using the formula developed by Lincoln (1930):

$$\frac{X(\text{Total population})}{669\ (\text{Total caught})} = \frac{267(\text{Total tagged})}{14\ (\text{Tags recovered})}$$

or: $X = 12{,}759$.

The estimated number of pickerel in Babcock Pond within the sizes tagged and available for anglers by artificial bait-casting methods was thus 12,759, or about 60 per acre. The validity of the population estimate would be greatly increased if enough recaptures had been made to provide a more even percentage distribution of recaptures in the total-length classes of those tagged. Thus, the validity of the sample is greatest for fish in the class of 11 to 12 inches total length since either the methods of capture were selective for this group or the median of the population was at this point. The work of Raney (1942) indicates a possible error in this method of estimating a fish population. After marking 20 adult pickerel with strap tags in the operculum, he recaptured several from which the tags had worked loose, leaving a semi-rectangular area without bone and consequently partially uncovered gills. No fish were taken with uncovered gills and tag mark at Babcock Pond, but his contention that jaw tags would prove more satisfactory was borne out by the fish tagged by us in 1940 and 1941. The tags inserted in the operculum all were loose upon recapture, while jaw tags were well grown over and usually had to be cut away from the lower jaw when the fish were retaken.

Measurements are available on 13 of the 14 fish recaptured in 1941. When tagged in 1940, they ranged from 10.5 to 16.5 inches and averaged 12.7 inches in total length; in 1941 they ranged from 10.8 to 16.7 inches and averaged 13.4 inches in total length. The minimum gain was by no. 159-S which failed to increase in length from July 3, 1940, when tagged, to June 13, 1941, when recaptured; and a maximum gain of 2.2 inches was recorded for no. 309, tagged on September 1, 1940, and recaptured on July 15, 1941. The average increase in length for all recaptures was only 0.7 inches, much less than the normal yearly increase in length for untagged fish of the same size class. Capture and tagging undoubtedly affected the normal growth rate.

Six fish which were fin-clipped in 1940 were recaptured later that seaon and all showed some fin regeneration. In some only the line of broken rays at the line of the cut serve to distinguish a completely regenerated fin from one which had not been cut. So far as known, none of the 114 fin-clipped fish was recaptured in 1941. Possibly the regenerated fins become so perfect in a year as to show no scar and make reidentification impossible.

During 1940, when a total of 154.75 hours were spent fishing, the average

catch per rod-hour was 4.2 fish; the comparable figure for 1941 from catch records totalling 205.25 hours was only 3.1 fish. When average catches per rod hour were determined for each month of 1940 and 1941, the figures showed a

TABLE 2.—DECLINE IN AVERAGE CATCH OF PICKEREL PER ROD HOUR.

	Totals		*Average per rod hour*
	Catch	*Hours*	
1940			
June	156	30	5.2
July	179	42	4.3
August	158	41	3.8
September	154	41	3.7
1941			
June	314	93	3.4
July	202	61	3.3
August	98	40	2.4
September	25	11	2.3

progressive decline from a high in June to a low in September for both years. Furthermore, the low average catch per rod-hour during September 1940 was higher than the high for 1941 in June (Table 2).

Unless fish became educated to the type of bait used, the reason for this regular decline through the season remains unknown; no correlation could be found between the decline and any weather factors or with daily time of fishing. Over 95 per cent of the fishing was done with bait casting rod and reel, but skittering, flyfishing, and some use of live-bait also were attempted. The lures most used by bait casters were the red and white and the silvered wobblers.

Most of the attempts were made between the hours of 6:00 and 8:00 P.M. due to a leisure time factor, because most of the fishermen were engaged in wildlife management work during other hours of the day. In all, 80 of the 172 attempts in 1940 and 1941 were made between 6:00 and 8:00 P.M., and only 25 attempts were made prior to noon. In over 80 per cent of the 119 attempts made in 1941, less than two hours was spent in each attempt, and only once did the angler fish longer than

TABLE 3. LENGTH-WEIGHT RELATIONSHIPS OF 208 EASTERN PICKEREL FROM BABCOCK POND, EAST HADDAM, CONNECTICUT, 1941.

Standard length class, cm.	*Average, cm.*	*Females*		*Males*	
		Number	*Average weight, grams*	*Number*	*Average weight, grams*
15.0–16.9	15.8	1	33.5	1	33.5
17.0–18.9	18.0	2	42.8	6	48.5
19.0–20.9	20.3	4	69.5	11	72.4
21.0–22.9	22.0	8	85.0	17	86.9
23.0–24.9	23.7	12	98.1	21	117.1
25.0–26.9	25.9	18	141.4	14	137.9
27.0–28.9	27.8	13	174.7	12	176.3
29.0–30.9	29.8	8	212.7	10	193.3
31.0–32.9	31.9	5	310.9	6	247.6
33.0–34.9	34.0	2	292.8	2	363.0
35.0–36.9	35.6	7	407.7	4	331.5
37.0–38.9	37.6	3	484.2	2	483.2
39.0–40.9	40.2	4	621.8	—	—
41.0–42.9	42.0	3	737.8	2	597.2
43.0–44.9	43.6	4	766.5	—	—
45.0–46.9	46.5	3	927.4	—	—
47.0–48.9	—	—	—	—	—
49.0–50.9	49.5	3	1176.8	—	—
TOTALS		100		108	

3½ hours. In 78 of the 119 attempts anglers fished from one to two hours.

Of the 639 fish caught in 1941, there were 211 taken for life-history study; additional life-history notes were compiled from those taken in 1940. Of the life-history group there were 108 males, 100 females, and three in which the sex could not be determined by gross examination.

No significant differences were found between the sexes in width, depth, total length, standard length, head length, or weight, but the weights of individuals varied considerably in relation to length (Table 3). Some variation resulted from the presence or absence of food in the alimentary canal; one fish weighing 367 grams had a partially digested golden shiner weighing over 50 grams in the stomach. Further variations in weight-length proportions occurred perhaps because the specimens for life-history study were taken during the period from June 9 to September 9, 1941.

During 1940, scales from 45 fish were read and a preliminary rate-of-growth graph constructed; scales from 162 others were collected in 1941 (Table 4). Table 6 shows the overlapping of fish in winter age classes II, III, IV by total length classes. This overlapping resulted from the method of collection; fish taken in September showing two annuli were nearly three years of age, whereas others showing two annuli taken in June or July had only passed their second winter.

TABLE 4.—LENGTH-AGE RELATIONSHIP IN 162 CHAIN PICKEREL, BABCOCK POND, CONNECTICUT, 1941.

Age in winters	*Average total length, inches*	*Percentage of all taken*
2	7.6	*17.9*
3	12.3	*46.3*
4	14.1	*21.0*
5	17.5	*8.0*
6	19.6	*3.1*
7	19.1	*3.1*

In 1940, 60 stomachs from adult pickerel were examined, but only 15 contained food; the leading item was

TABLE 5.—STOMACH CONTENTS OF 71 PICKEREL (15 TO 55 CM. TOTAL LENGTH), BABCOCK POND, CONNECTICUT, 1941.

			Records	
	Volume, cc.	*Percentage*	*Number*	*Percentage*
Pisces	210.2	*91.4*	51	*62*
Cyprinidae				
Notemigonus c. crysoleucas[a]	90.5		11	
Other species	0.2		1	
Esocidae				
Esox niger	47.3		7	
Siluridae				
Ameiurus n. nebulosus	45.8		11	
Centrarchidae				
Lepomis gibbosus	11.2		4	
Unidentified remains	15.2		17	
Amphibia, *Rana spp.*	11.0	*4.8*	3	*3.6*
Arthropoda	8.4	*3.7*	26	*32*
Odonata, larvae	7.2		19	
adults	0.1		1	
Unidentified aquatic insect larvae	1.1		6	
Vegetation	tr.		1	
Unidentified	0.2		1	
Totals	229.8		82	

[a] One stomach a golden shiner, volume 50.5 cc.

smaller pickerel. Common sunfish (*Lepomis gibbosus*), minnows, mostly the golden shiner (*Notemigonus c. crysoleucas*), but occasionally the bridled minnow (*Notropis bifrenatus*), and odonata larvae were also taken. In 1941, 211 stomachs were examined of which 71 (33.6%) contained food. Fish comprised over 90 per cent of the total volume and 62 per cent of the recorded items (Table 5). Prominent among those taken were the golden shiner and common bullhead, each recorded 11 times. Insects made up only 3.7 per cent of the contents. The average amount of food in stomachs was 2.8 cc. by volumetric displacement. Results from our food-habit study agree closely with those by Raney (1942) and by Hunter and Rankin (1939).

TABLE 6.—OVERLAPPING OF WINTER AGE CLASSES AS TO TOTAL LENGTH IN EASTERN PICKEREL.

Length class, inches	*Winter age classes*			*Totals*
	II	*III*	*IV*	
6.1– 7.0	1	—	—	1
7.1– 8.0	2	1	—	3
8.1– 9.0	4	10	—	14
9.1–10.0	8	18	1	17
10.1–11.0	9	17	2	28
11.1–12.0	2	15	4	21
12.1–13.0	3	8	3	14
13.1–14.0	—	3	8	11
14.1–15.0	—	—	7	7
15.1–16.0	—	—	3	3
16.1–17.0	—	—	5	5
17.1–18.0	—	—	0	0
18.1–19.0	—	—	0	0
19.1–20.0	—	—	1	1
Totals	29	72	34	115

Supporting the contention of Raney (1942), Table 7 indicates that the diet of smaller chain pickerel is almost entirely of insects and that of the larger individuals entirely of fishes. As the total length increased from 15.1 to 40.0 cm., there was a gradual decrease in the number and volume of insects taken and a rise in the number and volume of fishes eaten. There were no significant differences between the food of males and of females, and no seasonal differences from June to September.

Most of the pickerel taken for life-history study were examined for parasites with a binocular microscope; only two cases of extensive parasitism were noted. Determinations were made by Dr. L. R. Penner of the University of Connecticut. An external parasite (*Argulus versicolor*? Wilson, 1903) was common over the whole body and produced small bleeding areas, but was only occasional in the mouth and gill cavity; no heavy infestations were found. The only common internal parasite was *Azygia angusticauda* Stafford, 1904. Numbers were found in the alimentary canal in 87 pickerel examined particularly for this species. Only 27 has escaped infestation, 32 had few, 15 had moderate infestations, and in 13 the numbers of this parasite were large. Neither of these parasites affected the growth or condition of the fish materially, and, since they do not affect the palatability, they probably are of little significance in the management in Babcock Pond. Hunter (1942) after examining 53 chain pickerel from nine Connecticut lakes, recorded both of these parasites as "rare," in less than 9.9 per cent of the fish examined.

SUMMARY

A study of the eastern pickerel was made during the summers of 1940 and 1941 in a 200-acre bog pond at East Haddam, Connecticut, as part of a cooperative project between the East Haddam Fish and Game Club and the Department of Forestry and Wildlife

TABLE 7.—FOOD OF 71 CHAIN PICKEREL, BABCOCK POND, CONNECTICUT, BY LENGTH CLASSES.
(all figures are percentages; upper figure, by number; lower figure, by volume in cc.)

Total length, centimeters	Fish						Insects				Amphibians
	All fish	Pickerel	Golden shiner	Bullhead	Common sunfish	Fish remains	All insects	Odonata, adults	Odonata, larvae	Insect remains	
15.1–20.0							100 100		100 100		
20.1–25.0	64 97	9 23		9 40	9 7	37 27	55 3		55 3		
25.1–30.0	71 82	3 1	19 33	23 20	3 1	32 28	39 9		35 8	3 1	
30.1–35.0	60 76	13 31	20 22	7 18	7 15	13 19	26 4	7 Tr.	27 3	7 Tr.	20 20
35.1–40.0	88 99	14 8	14 55	28 34	14 1		14 Tr.		14 Tr.		
40.1–45.0	100 100	100 100									
45.1–50.0	100 100		50 1	50 99							
50.1–55.0	100 100	50 45	50 55								

Management, University of Connecticut. Over 1200 fish were caught by rod and line for tagging, fin-clipping, and life-history data. Best results in marking were obtained with a small strap tag in the lower jaw.

On the basis of tags recaptured in 1941, the population was computed as about 60 fish per acre, and ranging in total length from 6 to 22 inches. Of all fish caught, about 64 per cent were less than the minimum legal length of 12 inches.

Average catches per rod-hour decreased from June 1940 to September 1941, possibly because fish became educated to the type of bait offered. The average of all anglers in 118 attempts was 3.1 fish per rod-hour.

In a sample of 211 pickerel taken for life-history study, the sex ratio was 108 males to 100 females. No significant differences were found between the sexes in rate of growth or food habits. Of 211 stomachs examined, 71 (33.6%) contained food. Fishes made up 91 per cent of the total volume and 62 per cent of the recorded items; insects comprised only 3.7 per cent by volume, but were recorded from 32 per cent of the stomachs containing food. As the total length of the pickerel increased from 15 to 40 cm. there was a gradual decrease in the number and volume of in-

sects eaten and a steady increase in the number and volume of fishes taken. Smaller pickerel fed almost entirely upon insects.

Two parasites, *Argulus versicolor*? Wilson, 1903 and *Azygia angusticauda* Stafford, 1904 were found, the latter in 60 of 87 fish examined.

LITERATURE CITED

ADAMS, C. C., and T. L. HANKINSON. 1928. The ecology and economics of Oneida Lake fish. Roosevelt Wild Life Annals, 1: 237–548.

CLARK, A. L. 1936. Connecticut State Board of Fisheries and Game. Bien. Rept., 21, 107 pp. Pub. Doc. 20.

HUNTER, G. W., III. 1941. Studies on the parasites of fresh water fishes of Connecticut *in* "A fishery survey of important Connecticut Lakes." Conn. Geol. and Nat. Hist. Surv. Bul., 63: 228–288.

HUNTER, G. W., III, and J. S. RANKIN, JR. 1939. The food of the pickerel. Copeia, 1939: 194–199.

KENDALL, W. D. 1917. The pikes: their geographical distribution, habits and culture, and commercial importance. U. S. Bur. Fisheries, Ann. Rept., Appendix, 1917 (Doc. 853): 1–45.

LINCOLN, F. C. 1930. Calculating waterfowl abundance on the basis of banding returns. U. S. Dept. Agric. Circ., 118.

RANEY, ED. C. 1940. Summer movements of the bullfrog, *Rana catesbeiana* Shaw, as determined by the jaw-tag method. Amer. Midland Nat., 23: 733–745.

1942. The summer food and habits of the chain pickerel (*Esox niger*) of a small New York pond. Journ. Wildl. Mgt., 6: 58–66.

SMITH, M. W. 1939. The fish population of Lake Jesse, Nova Scotia. Nova Scotian Institute Science, Proc., 19: 389–427.

WEBSTER, D. A. 1942. The life histories of some Connecticut fishes *in* "A fishery survey of important Connecticut lakes." Conn. Geol. and Nat. Hist. Surv. Bul., 63: 122–227.

RELATIONS OF THE AMERICAN COOT WITH OTHER WATERFOWL

Clarence A. Sooter

U. S. Fish and Wildlife Service, Tule Lake, California

The American coot (*Fulica americana*) has increased markedly within recent years and on many western areas far outnumbers the ducks. For example, of the 45,000 to 50,000 waterfowl on Boca Lake, Malheur Refuge, Oregon, during October and November 1943, about 32,000 to 37,000 were coots; and on another part of the refuge the ratio was one duck to six coots. There were, of course, noticeable variations in the ratios on various lakes. On the Lower Klamath and Tule Lake refuges there were an estimated 350,000 coots, and the approximate ratio was one coot to four ducks or geese.

These numbers and proportions give rise to the question of coot-duck relationships. Is the coot sufficiently pugnacious to limit the use of nesting cover by other waterfowl? Is it antagonistic to duck broods? Is its relationship such as to reduce production among other species of marsh nesting birds? These questions confront managers of all waterfowl areas on which the coot now

breeds. Studies on waterfowl by various naturalists provide only limited evidence on the subject.

Low (1940) recorded coots and pied-billed grebes in Iowa nesting within a yard of redhead nests, "without causing nest failure to any of the [latter] birds." In 1937, the writer found ruddy ducks appropriating coot nests in Iowa. Low (1941) also noted this marsh relationship. Friley, Bennett, and Hendrickson (1938) make no mention of antagonistic action of coots toward other birds nesting at Mud Lake, Iowa. After listing the birds nesting on that area in 1935, however, they state that "in 1932 there were at least twice as many coots on the marsh, but no diving ducks, no eared-grebes, and other species were less numerous." It is debatable, of course, whether or not the larger coot concentration in 1932 was responsible for the smaller nesting population of the other species. Bennett (1938), in his work on the blue-winged teal, found a coot, sometimes two or three together, "chasing teal away from certain areas in the marshes." He observed, however, that no teal was evicted from a desirable nesting area by coots.

During the summer of 1943, this subject was studied on the Malheur National Wildlife Refuge, Harney County, Oregon, and frequent observations were made on coot relationships during both the courting and nesting periods. In general, these observations followed a similar pattern with regard to the species involved. The relationships may be illustrated by typical field observations.

June 2. In mid-afternoon one female and two male ruddy ducks were close to a coot nest containing young and eggs. The two males entered the clump of bulrushes around the nest and were immediately chased away by the adult coot. One male was chased three times, and in each instance escaped by diving. The other ruddy duck was not interfered with, although it swam near the coot nest and rested there for a time; nor was the female duck disturbed when she approached to within 10 or 15 feet of the coot nest. A pied-billed grebe likewise swam near the nest and was not molested.

During the same time two male and one female redhead, and a pair of each of gadwall, cinnamon teal, and mallard were feeding close to a pair of coots. The latter showed no antagonism in this feeding area, but when the gadwalls approached a pair of coots feeding their young, one of the coots uttered a growl-like note and chased the two ducks away. Later they returned to the territory in which the young coots were being fed only to be driven off a second time.

At 4:40 P.M. another coot was seen molesting a gadwall. Later the same afternoon, in another marsh area, a drake mallard swam through five coot brooding territories without being bothered by the adult coots present.

June 3. Five male and two female ruddy ducks swam near two broods of feeding coots; no antagonism was shown. But a male redhead swam hurriedly aside when confronted by a coot in the marsh. The same redhead loafed for a time in some open water, but swam away when a coot approached. Later, however, the redhead was resting within four feet of a coot feeding its young.

At 12:30 P.M. a coot rushed at a yellow-headed blackbird that alighted

near by. The same coot attacked drake mallards on five occasions causing them to fly or swim off a short distance, and it also made a 40-yard dash to drive away another coot.

Two pairs of gadwalls, three pairs of redheads, and one pair of cinnamon teal were unmolested in the territories of other coots. The redheads, however, were cautious and avoided approaching any coots. Four female and five male ruddy ducks in a courting group were bothered only once by adjacent coots.

At 3:30 P.M. one pair of cinnamon teal was driven from the vicinity of a coot nest in another marsh near by.

June 9. In an area containing both coots and ducks, the ducks did not enter territories immediately adjacent to those where young coots were being fed.

June 19. The first antagonism of coots toward ducklings was observed. A coot chased a stray gadwall duckling, which finally escaped by diving. The same coot also molested two half-grown coots near by. Another coot molested and chased a brood of gadwalls, but the female gadwall attending the brood drove the coot away, and this action was once more repeated. Shortly, a different adult coot chased a lone juvenile coot past two young ducks; these paid no heed to the coots and the latter made no move towards the ducklings. In two instances gadwall females protected their young from coots; one brood was of quail size.

July 21. Three adult gadwalls in a coot territory were attacked.

July 31. A brood of five ruddy ducks was molested by a pugnacious coot; the latter apparently was afraid of the parent ruddy duck and avoided her when she gave chase. This same duck also chased other coots which approached her brood too closely.

DISCUSSION

The above observations give some indication of the degree of compatibility of the coot to other waterfowl. As a species, coots are definitely more pugnacious than most waterfowl in the breeding marshes, but there is considerable variation between individuals. Undoubtedly their temperament varies with locality and circumstance. Coots appear to resent birds of other species entering their nesting territories. Under such conditions they chased young coots, duck broods, and adult ducks. They also protect their own territories to some extent throughout the brooding season. Toward the end, however, this antagonism wanes, and there is more tolerance of territorial encroachment in places where both coots and ducks with broods previously had been forced to stay clear of coot nesting territories and territories for feeding young. As early as August 3 in one locality, old and young coots and ducks with broods were mingling together with no antagonism being shown by the coots towards the ducks.

Redheads were especially prone to avoid the pugnacious coots. Ruddy ducks and gadwalls with broods, however, usually gave good accounts of themselves when coots showed antagonism. There was no evidence that the coots actually harm young ducks, since careful search yielded only one questionable case—a duckling with a skull laceration. From the standpoint of predation, the data do not show the coot to be a serious menace to waterfowl production. Munro (1939), in British

Columbia, arrived at much the same opinion.

The influence of coots on the productivity of waterfowl breeding areas cannot be measured adequately by observation. This approach, nevertheless, permits the inference that coot pugnacity reduces, to an unknown extent, the number of nesting sites available to other species. When the coot population is large, competition for nesting sites may be an important limiting factor, particularly with the ruddy duck. Furthermore, the coots, by protecting their own brooding areas, influence the attractiveness of such places as feeding grounds for ducks. On lakes and marshes where food is limited, this might bear importantly on the production of ducks. Even in waterfowl habitats that have ample food supplies, the coots may reduce utilization by other species when they far outnumber the latter.

On areas where observations indicate that coots may be limiting the production of other birds, it would seem wise to initiate more intensive studies to determine the exact relationships, but any efforts at control of coots should be delayed until the results of such studies are available.

LITERATURE CITED

BENNETT, L. J. 1938. The blue-winged teal, its ecology and management. Ames, Iowa, Collegiate Press. 144 pp.

FRILEY, C. E., JR., L. J. BENNETT, and G. O. HENDRICKSON. 1938. The American coot in Iowa. Wilson Bul., **50**: 81–86.

LOW, J. B. 1940. Production of the redhead (*Nyroca americana*) in Iowa. Wilson Bul., **52**: 153–164.

1941. Nesting of the ruddy duck in Iowa. Auk, **58**: 506–517.

MUNRO, J. A. 1939. The relation of loons, Holboell's grebes, and coots to duck populations. Journ. Wildl. Mgt., **3**: 339–344.

LIVE TRAPPING OF HAWKS AND OWLS

Robert E. Stewart, James B. Cope and Chandler S. Robbins

Patuxent Research Refuge, Bowie, Maryland

Many birds have been trapped and banded in the past few years at the Patuxent Research Refuge near Bowie, Maryland. Between July 1939 and July 1944, 7387 individuals of 116 species were banded on the 2,680-acre area in connection with intensive studies on the relationships of birds to their environments.

Large scale trapping of hawks and owls extended from November 1, 1943, through May 26, 1944, and much was learned about methods of capturing these birds. Since little previous attention has been given to large-scale live-trapping of hawks and owls, the present paper may help to (1) promote selective control of hawks and owls around game farms and poultry yards, and (2) contribute information on the habits of these interesting and little-known birds.

MISCELLANEOUS TRAPS

Several different types of traps were used, with varying success. The first was an automatic trap with live bait,

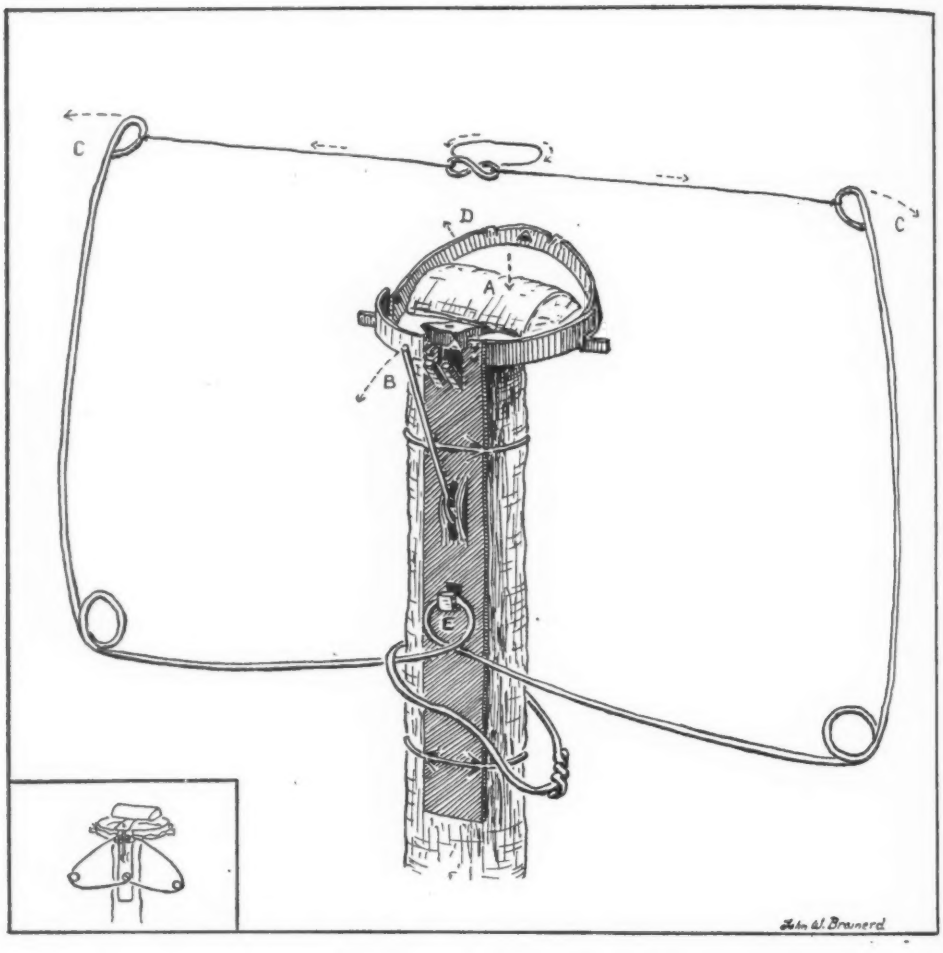


Fig. 1. Structure and action of the Verbail leg-hold trap used for hawks and owls. Pressure of the bird's feet on the wooden pan (*A*) tips the lever and disengages the pin (*B*) which has been holding ends of the wire spring (*C*) on projections beneath the lever. The ends of the spring move outward and upward, lifting the noose off the supporting ring (*D*) which is hinged in the middle to aid in throwing the noose off and upward around the bird's legs. At the same instant the noose constricts, drawing the legs snugly against the figure 8 (of wire) which rested against the outside of the pin when the trap was set (see inserted figure). The spring lifts off the hook (*E*) and slides down the pole with the noose and the bird, so that the latter does not dangle when trapped.

employing the principle of the ordinary drop trap sometimes used for mammals. Two Cooper hawks eventually were caught, but so much time and effort were involved in baiting and attention that the trap was deemed impractical and is not described in detail.

A bow-net trap, such as used by falconers, was fairly successful; it was operated with a pull string, by a person concealed in a blind, and required considerable time. This trap furnished excitement and sport to the user, and was quite productive at times. Using live pigeons for bait, six red-tailed and two Cooper hawks were caught; several other species came down to the bait but were lost through the inexperience of the operator. From a practical point of view, it would be desirable to operate this trap only during the height of a hawk migration.

Pole traps, such as used by many game farms to control hawks and owls, were next tried, with 54 steel traps generously loaned by the Pennsylvania Game Commission. These were similar to the standard traps for taking furbearers, but had a greater length of pan and the jaws were rectangular rather than rounded. The jaws were well padded by winding on strips of burlap and tar tape; then the traps were placed on poles 7 to 12 feet in height. These padded steel traps were fairly successful for catching hawks and owls, but not very satisfactory from the humane standpoint, since several birds were found with injured legs.

VERBAIL POLE TRAP

Shortly after the padded steel traps were put in operation, it was learned that the Animal Trap Company of America (Lititz, Pa.) had constructed a modification of the Verbail trap originally invented by Vernon Bailey. This trap is reputed to be both humane and efficient. Through the courtesy of Mr. Harry Van Cleve of the Animal Trap Company, 30 of the traps were loaned for field trial.

The Verbail trap consists essentially of a wire spring which throws a noose around the legs of a bird when pressure is exerted on the pan. The bird is held by a loop of light cord instead of heavy rigid jaws, and is not likely to injure its legs in efforts to escape (Pl. 3; Fig. 1). In setting the trap care must be taken to see that the hoop of stiff wire connecting the spring with the pole is sufficiently small in diameter so that the bird will not be able to work it off over the standard and escape with the noose and spring still attached to its legs. Despite precautions, several birds escaped in this way and two were not found until they had died of starvation. With the cord well waxed, the ring hinges and spring oiled, and the standard well painted, this trap has operated efficiently through nearly a year of continuous service. Another advantage over the steel trap is the hair-trigger adjustment of the Verbail trap enabling it to catch the smaller hawks and owls as well as the large species.

RESULTS

An analysis of the eight best trap locations, with particular emphasis on the type of habitat in which poles were located, is presented in Table 1. This is not a comparison between the padded steel and Verbail traps, since the conditions under which the two types operated were not identical. The Verbails

TABLE 1.—ANALYSIS OF EIGHT BEST POLE TRAP LOCATIONS.

No.	Habitat	Type of trap	Days in operation	Total catch		Percentage
				Hawks	Owls	
1	Center of marsh bordered by shrub swamp	Steel	28	0	1	*3.6*
		Verbail	90	7	8	*16.7*
2	Hill overlooking lake	Steel	—	—	—	—
		Verbail	116	10	1	*9.5*
3	Abandoned orchard between deciduous woods and dwellings	Steel	32	0	2	*6.3*
		Verbail	40	1	3	*10.0*
4	Marshy meadow with series of small artificial ponds	Steel	—	—	—	—
		Verbail	60	3	2	*8.3*
5	Edge of wheat field, 25 ft. from brook with hedgerow	Steel	—	—	—	—
		Verbail	117	6	2	*6.8*
6	Wet spot in unharvested soybean field bordered by bottomland forest	Steel	60	0	1	*1.7*
		Verbail	46	3	3	*13.0*
7	Center of ¼ acre marsh bordered by forested swamp and abandoned fields	Steel	41	1	1	*4.8*
		Verbail	77	1	4	*6.5*
8	¼ acre broomsedge field between winter wheat field and forested swamp	Steel	49	1	1	*4.0*
		Verbail	44	3	0	*6.8*

were set in the better locations and the steel traps, which they replaced, were tried in other habitats. All of the owls listed in Table 1 were barred owls. The hawks were red-shouldered hawks except as follows: Location 2 yielded 3 red-shouldered hawks, 3 sparrow hawks, 3 Cooper hawks and 1 sharp-shinned hawk; Location 3 produced 3 red-shouldered hawks and 3 sparrow hawks.

An effort was made to place the pole traps in areas where small mammals and birds were abundant, or in exposed places that offered a commanding view of the surroundings. Traps in fields or clearings and near hedgerows or wood margins were especially successful, as were those in small marshy areas. The height of the pole should be greater than that of the surrounding vegetation, so that a conspicuous perch is readily discernible to any incoming hawk or owl.

A comparison of the local status of each species with the total number trapped is given in Table 2. All species known to have occurred on the refuge are included, except for the osprey and bald eagle which would require special trapping methods.

Table 3 is a summary of all captures during the trapping period. Banded birds retrapped during the study are designated as "repeats."

The fact that hawks and owls often repeat in the pole traps would indicate that they are not adversely affected by such experiences. Of nine different barred owls that repeated, one returned to the traps four times, one three times, three twice, and four once. Three owls repeated in the same trap at which the original capture was made; one of these returned to the same trap only two days following its initial capture.

TABLE 2.—RELATION OF CAPTURES TO ABUNDANCE OF HAWKS AND OWLS.

Species	*Number trapped*	*Local status*
Goshawk	0	Very rare (1 record); none in period
Sharp-shinned hawk	2	Common migrant, rare in winter
Cooper hawk	7	Common migrant; uncommon summer and winter
Red-tailed hawk	7	Common migrant and winter resident; rare in summer
Red-shouldered hawk	37	Very common migrant and summer resident; common in winter
Broad winged hawk	2	Common migrant and summer resident
American rough-legged hawk	0	Very rare (2 records)
Marsh hawk	0	Uncommon migrant and winter resident
Duck hawk	0	Rare migrant (2 records during study)
Pigeon hawk	0	Rare migrant (2 records during study)
Sparrow hawk	25	Very common migrant; uncommon winter; rare summer
Barn owl	3	Uncommon
Screech owl	0	Rare (no record during study)
Great horned owl	1	Uncommon
Barred owl	31	Very common
Long eared owl	1	Very rare (1 record)
Saw-whet owl	1	Very rare (1 record)

CASUALTIES

Occasional trapping casualties can be expected even in Verbail traps. The number of injuries can be reduced considerably if the traps are visited at least three times a day: in the early morning, at midday, and in the evening. On hot or rainy days it is preferable to make at least four visits.

During the six months of trapping, only one bird suffered a broken leg, a red-shouldered hawk taken in a padded steep trap. Four raptors were lost to predators and two were found dead in traps not visited as frequently as desirable. Some individual hawks and owls attempted to free themselves by biting their legs; this resulted in a limited amount of injury, usually superficial. One Cooper hawk, however, severed a large blood vessel in its leg and died as a result.

TABLE 3.—SUMMARY OF CAPTURES IN ALL TYPES OF TRAPS.

Species	Totals	Number of captures[a] in				
		Verbail	Padded steel	Bow-net	Small bird[b]	Misc.
Sharp-shinned hawk	2	1	0	0	1	0
Cooper hawk	7	4	0	2	1	0
Red-tailed hawk	7	0	0	6	0	1
Red-shouldered hawk	37 (9R)	32 (8R)	4	0	0	1 (1R)
Broad-winged hawk	2	1	1	0	0	0
Sparrow hawk	25 (4R)	17 (3R)	0	0	8 (1R)	0
Barn owl	3	3	0	0	0	0
Great horned owl	1	0	0	0	0	1
Barred owl	31 (17R)	22 (13R)	9 (2R)	0	0	0 (2R)
Long-eared owl	1	1	0	0	0	0
Saw-whet owl	1	1	0	0	0	0

[a] Repeats, in parentheses, not included in the totals.
[b] Automatic traps set on ground for passerine birds.

SONG BIRDS

Only four birds other than hawks and owls were captured in the pole traps, three bluebirds and one flicker. One bluebird and the flicker had been killed by predators when found. A second bluebird suffered a leg injury and the third was released apparently unharmed.

CROWS AND VULTURES

Rather surprisingly no crows or vultures were caught in any of the pole traps. Four crows and three turkey vultures were taken in steel traps set on the ground for fur-bearing mammals and 23 turkey vultures and two black vultures were caught in a large Australian crow trap. By baiting pole traps with carrion, vultures and even crows might be taken.

SELECTIVE CONTROL

Under conditions on the Patuxent Research Refuge, the Verbail pole trap has proved a great success in the live-trapping of hawks and owls, particularly the species present in greatest abundance. The numerical status of the various species, as compared with the number trapped (Tables 2 and 3), will give some idea of the efficiency of this trap for the various species. On the whole, beneficial species were taken more readily than harmful ones. Since this same ratio holds true for the use of pole traps in general, the advantage of the Verbail trap over the unpadded pole traps now in use by game farms is obvious. It is likely that the use of baits with Verbail traps would yield a larger proportion of the bird-eating species.

SUMMARY

1. Hawks of six species (80 individuals) and owls of five species (37 individuals) were trapped for banding from November 1, 1943, to May 26, 1944.

2. In general, pole traps proved better than hand-operated traps or automatic traps using live bait.

3. Verbail pole traps proved very efficient, and were much more humane than padded steel traps because they rarely injured a captured bird.

4. Unbaited Verbail traps took a variety of raptors, in rough proportion to their local abundance, although slightly more of beneficial species were caught than of harmful types.

5. Hawks and owls were retrapped more readily in Verbail traps than in other types tried.

6. The number of song birds caught in Verbail traps was negligible.

7. Crows and vultures were not taken in Verbail traps, but possibly could be caught with bait.

e use of
ıtage of
padded
arms is
use of
yield a
l-eating

0 indi-
(37 in-
banding
May 26,

ved bet-
or auto-

very ef-
humane
use they

took a
oportion
although
ies were

etrapped
than in

s caught
e.
ere not
possibly

Verbail leg-hold trap. *A*. In position on post. *B*. Red-shouldered hawk caught in trap. *C*. Removing a hawk from the trap. *D*. Resetting the trap.

UNIV. OF MICH.

PICKING AMONG PEN-REARED BOBWHITE QUAIL

Ralph B. Nestler, Don R. Coburn and Harry W. Titus

U. S. Fish and Wildlife Service and U. S. Bureau of Animal Industry, Washington, D. C.

Quail are normally wild creatures and for the stocking of depleted or new areas it is desirable that their wildness be maintained. Life in captivity is abnormal, especially under modern systems of propagation. The birds are hatched in incubators, brooded under electric hovers, and reared to the age of liberation in small, low-ceiled pens, generally with wire floors. Several weeks even may be spent indoors, in brooder batteries. Primarily to avoid the hazards of disease, is has been feasible to rear them completely apart from range conditions. In any unnatural environment trouble can be anticipated.

Cannibalism is a major cause of losses among game birds reared in captivity, and there have been numerous and somewhat conflicting recommendations for preventing or alleviating this scourge. This report summarizes information on the subject and presents evidence for best control procedures.

Toe-picking and beak-picking, the more common manifestations of cannibalism in bobwhite quail (*Colinus virginianus*), may start several days after the chicks hatch; usually it is most severe during the first two weeks but may appear at any age. Mortality from picking up to 45 per cent has been reported among young quail.

Picking is less prevalent among adults than chicks, but feather-picking and foot-picking occasionally appear in pens of bobwhites held through the winter. Fighting, which should not be confused with true picking, may start spontaneously and without apparent cause, but generally occurs when one or more strange birds are added to a covey, when two coveys are combined, or when the breeding season starts. Victims of fighting usually suffer severe head injuries and are found cowering in one corner of the pen.

Possible Dietary Causes

Lack of oats or fiber in diet

Ewing (1941), in discussing cannibalism among chickens, states that "insufficient fiber in the diet, which may result from eliminating oats, appears to be one of a number of causes of cannibalism." This assumption was based primarily on researches by Kennard and Chamberlain (1936) in Ohio, and by Bearse, Miller and McClary (1938–39, 1940) in Washington. The latter workers found that oat-hull fiber, obtained by dilute acid digestion of oat hulls, controlled picking when fed at a level sufficient to produce a ration containing 11 per cent of fiber. The entire oat hull was equally efficacious but two other fractions, the ash of the dilute acid extract and the water extract, were of little value in preventing cannibalism. Ground corn or corn meal is somewhat deficient in manganese and, when used in large proportions, tends to in-

crease cannibalism as compared with ground oats.

During 1940 and 1941 several experiments were conducted at the Patuxent Research Refuge, Bowie, Maryland, with pen-reared bobwhite chicks to determine (1) the comparative value of various grains in the growing diet of the quail, and (2) the effect of various levels of fiber. All diets were formulated to contain 28 per cent of crude protein, 1 per cent of calcium, and 0.7 per cent of phosphorus, together with about 9400 I.U. of vitamin A and 545 I.U. of vitamin D per pound. Sufficient manganous sulfate was added to provide 100 p.p.m. of manganese. Precautions were taken to prevent crowding among the birds and to maintain optimum brooding temperature.

One series of four experiments, involving 1,325 quail chicks, compared nine individual grains and two grain mixtures as constituents of growing diets. The percentage of victims from picking on each of the several types of grain were as follows: mixture of yellow corn, wheat middlings and oat groats *26;* oat groats *24;* yellow corn *16;* rye *13;* wheat *11;* barley *11;* oats *10;* millet *10;* corn and millet mixed *9;* kaffir *8;* and buckwheat *6*.

In another series of studies with 1,044 bobwhites, considering only three cereals, the incidence of cannibalism, expressed as percentages of total chicks, was as follows: barley *10;* oats *8;* yellow corn *8*.

Thus picking, primarily of beaks and toes, occurred on all the grains. Oats showed no preeminence over the other foods as a preventative for picking, and results were no better on cereal mixtures than on individual grains.

In a study of the effect on quail chicks of various levels of fiber in a growing diet, the incidence of picking among 940 bobwhites was as follows:

Percentage of fiber in diet:
1 2 3 4 5 6 7 8 9 10 11

Percentage of chicks picked:
31 5 22 33 19 10 42 28 23 15 20

The fiber content of the diet had no significant effect on the occurrence of picking. The disorder was as serious on 9 per cent fiber as on 3 per cent. Likewise, the source of the fiber, whether alfalfa meal or ground wood pulp, had no noticeable effect.

In the studies with various grains and levels of fiber, mentioned in the preceding paragraphs, and in other studies considered beyond, there were one or two pens on nearly every kind of diet in which picking never occurred, even though duplicate pens on the same experiment might have had a severe outbreak.

It should be emphasized that these data merely show the presence of picking and cannot be used to evaluate the picking-preventative qualities of the feedstuffs because they do not give a true index regarding the extent of the trouble. The extent of picking can not be judged correctly by the number of victims (a figure readily obtainable) but only by the number of culprits, which is difficult to determine. Even in pens where there are many victims, generally only a few birds are responsible for the trouble. In some cases a single pugnacious bird will injure many of his pen-mates and in others several vicious quail will attack a few. The authors think that the scourge would be more extensive and less readily con-

trolled in the latter situation than in the former. Generally the culprits are the larger birds and their victims often are among the smallest. If diet-deficiency is a major cause of picking, then certain individuals evidently have a higher requirement for the deficient factor or factors than others. Eventually the example set by those few maladjusted individuals may be followed by others whose requirements have been met by the feed.

CONSISTENCY OF FEED

The coarseness or fineness of the feed may have some effect on the disorder. In five experiments, involving 783 quail chicks, three different types of grindings of corn, oats, and barley were compared. The grains were ground in a hammer mill. The percentage of bobwhites picked on each of the three grinds was as follows: 2/32″ mesh screen, 14; 3/32″ mesh screen, 3; 4/32″ mesh screen, 10. For each of the three cereals the incidence of the trouble was lower on the grind from the 3/32″ mesh screen than on that from either of the other two screens. No picking occurred in any one of the three pens receiving the corn meal ground with the 3/32″ mesh screen.

NEED OF ANIMAL PROTEIN

Bass (1939a, 1939b), in studies with young gamebirds, concluded that "if, in addition to the usual diet, the birds are fed all the ground raw meat they will eat, and if it is kept before them all the time, nosepicking does not develop. Or, if it has already started, it stops as soon as they take to the raw meat." His results indicated that a lack of animal protein in the diet of penreared quail might be the cause of picking.

Adult bobwhites in the wild are largely vegetarian but the chicks, like the young of many other birds, take insects and other animal matter. Handley (1931) states that "during the first two weeks of existence, young bobwhites, as with the young of practically all other land birds, consume a much greater proportion of animal food than do their parents. Of the food of 20 chicks under two weeks of age, 83.7 per cent consisted of animal matter, compared with 22 per cent in 154 adults collected during the same period."

In three experiments with quail chicks at the Patuxent Refuge, diets containing protein concentrates from animal and plant sources were compared. These diets were balanced to supply 28 per cent crude protein, 1.1 per cent calcium, 0.7–0.8 per cent phosphorus, and comparable levels of vitamins A and D, thiamin, pantothenic acid, and riboflavin (except in that with buttermilk as the sole protein concentrate). The consequent incidence of picking (Table 1) was as high on diets containing animal protein as on those containing no animal protein. Most of the cases occurred during the first two weeks. Picking was absent only in the diet containing 22 per cent soybean oil meal, 10 per cent dried buttermilk, and 14 per cent sardine fish meal, but such results cannot be considered conclusive on the basis of present data. In the same experiment, only two mild cases of picking occurred on a diet containing 44 per cent soybean oil meal and 10 per cent dried buttermilk, whereas there were 16 in one containing 33.5% soybean oil meal, 10 per cent dried buttermilk, and 9 per cent meat and bone scrap.

Certain propagators of quail claim

TABLE 1.—THE OCCURRENCE OF PICKING ON VARIOUS PROTEIN CONCENTRATES.

Mash Containing	Number of birds on each diet	Percentage of birds victims of picking
Linseed oil meal 65%	48	21
Cottonseed oil meal 56%	96	49
Peanut oil meal 49%	96	51
Soybean oil meal 48%	96	24
Soybean oil meal 27.3%, linseed oil meal 27.3%	48	40
Soybean oil meal 44%, dried buttermilk 10%	36	6
Soybean oil meal 27%, dried buttermilk 10%, peanut oil meal 10%, linseed oil meal 10%	36	11
Soybean oil meal 26%, dried buttermilk 10%, peanut oil meal 10%, cottonseed oil meal 10%	36	11
Soybean oil meal 42%, dried buttermilk 16%	72	22
Soybean oil meal 38%, meat and bone scrap (protein 50%) 9%	96	38
Soybean oil meal 37%, meat scrap (protein 55%) 9%	96	29
Soybean oil meal 36%, menhaden fish meal 9%	96	21
Soybean oil meal 26%, sardine fish meal 14%	96	16
Soybean oil meal 33.5%, dried buttermilk 10%, meat and bone scrap (protein 50%) 9%	36	44
Soybean oil meal 31.6%, dried buttermilk 5%, sardine fish meal 5%, meat scrap (protein 55%) 5%	72	33
Soybean oil meal 30%, dried buttermilk 10%, sardine fish meal 5%, meat scrap (protein 55%) 5%	36	11
Soybean oil meal 30%, dried buttermilk 10%, menhaden fish meal 10%	36	6
Soybean oil meal 22%, dried buttermilk 10%, sardine fish meal 14%	36	0
Dried buttermilk 67%	48	29

to have prevented picking during the first two weeks of brooding by feeding hard-boiled chicken eggs crumbled with growing mash once or twice a day. The senior author conducted a test with two lots of quail on the same growing mash, with one receiving crushed hard-boiled eggs in addition. No picking occurred during the first two weeks on either lot.

EFFECT OF SALT

Prentice (1933), Newman (1935), Titus (1941), and Halpin and Holmes (1941) have discussed the efficacy of common salt in the control of cannibalism among domestic fowl. Titus maintains that feather picking and cannibalism can be stopped almost overnight by the addition of 0.5 to 2.0 per cent sodium chloride to the feed for four or five days. According to Newman the beneficial effects which accompany the use of salt appear to be a function of the sodium rather than the chlorine. Halpin and Holmes believe that "it would not be wise . . . to regard salt as a cure-all for cannibalism, but rather to recognize that a deficiency of salt very often causes the trouble." They suggest a "salt water cure" consisting of "one tablespoonful of salt in each gallon of drinking water for one forenoon, then about three days later repeating the treatment for another half day." According to these workers, this "cure" has given successful results with pheasants and turkeys as well as chickens.

Nestler (1941) stated that "preliminary studies . . . on cannibalism among adult bobwhites indicate that a deficiency of common salt in the diet is

one of the factors, if not the main factor, leading to the vice." This statement was made after that author and his associates had phenomenal success in stopping picking among quail maintained through the winter by increasing the salt content of the diet for several days after other measures had failed. The initial salt content usually was 0.5 per cent.

Shortly thereafter a questionnaire on picking was mailed to propagators of upland gamebirds throughout the country. The replies from 222 breeders were as follows:

13 had no trouble (3 used 1% salt in the diet);

124 had some trouble but mentioned no corrective measures;

8 used without success such "curatives" as (a) darkening the pens, (b) feeding raw beef, blood meal, or beet pulp, (c) applying noseguards, spectacles, or helmets to possible culprits, or (d) applying tar or "anti-picking" chemicals to prospective victims;

30 claimed to have prevented or checked cannibalism by one of the following measures: providing good range, feeding cut greens, crab meal, raw meat, meat meal, custard, crumbled hard-boiled eggs, canned dog food, hamburg steak and maggots, or chopped beets in separate containers, hanging up salted codfish or bacon strips within reach of the birds, increasing the floor space per bird, using pelleted feed, clipping beaks, mixing a special mineral mixture in diet, or providing pine needles for litter;

47 used salt with the following degrees of success: one had more picking after increasing the salt to 3 per cent than before, five had no satisfactory results even with salt content to 6 per cent, five had partial success (one found some lots of salt more effective than others; another that iodized salt was better than plain salt), 28 had good to excellent results, and eight made no comments. Three gave strong testimony favoring the use of salt to prevent picking; one declared that iodized salt added to drinking water had successfully checked the habit during 12 years.

As a result of the beneficial effects of salt on adult quail during the winter of 1939–40, a 2 per cent level of the following mixture was used in all growing diets during the spring and summer of 1940:

Common salt	2,000.0 parts
Anhydrous ferrous sulphate	11.0
Anhydrous manganous sulphate	17.0
Potassium iodide	0.2
Anhydrous copper sulphate	0.2

Preliminary tests (Nestler, 1943) showed that many newly-hatched quail tolerated up to four times this level of salt for the first two weeks, but later evidence indicated that a few may be adversely affected if their feed at all times contains as much as 2 per cent of salt or a salt mixture such as that above-mentioned.

The mortality from picking during the first two weeks of brooding dropped from 11.0 per cent in 816 chicks brooded during 1939 to 9.2 per cent of 1,704 brooded in 1940, In 1940, however, 28 outbreaks of picking occurred, five being severe. Most of the outbreaks were checked almost immediately by sprinkling more common salt on the feed in the hoppers.

An experiment in which potassium chloride and sodium sulphate separately were substituted for sodium chloride showed that neither prevented picking, and both were less effective than common salt.

During the breeding season of 1941, only 1 per cent of the saline mixture was added to the growing diets (only the sodium chloride was reduced, the other constituents remaining at the same levels). Toe-picking and beak-picking, in various degrees of severity, occurred in 96 of 144 pens of growing quail. Sixty

per cent of the outbreaks were checked by the sprinkling of salt on feed in the hoppers. In most cases the trouble did not recur, but in a few a second and even a third application had to be given. The remaining 40 per cent of outbreaks was not checked by salt, even after four or five applications. These included all pens of the "fiber" studies and those of the "protein" studies (Table 1) given the diet of 37 per cent soybean oil meal and 9 per cent meat and bone scrap (50% protein). In two of the last-mentioned pens nothing short of a complete change of diet checked the vicious habit.

Later it was discovered that picking could be checked as effectively by placing a hopperful of some feed concentrate such as fish meal, soybean meal, liver meal, or chopped fresh greens in the troublesome pen for a day or two, as by increasing the salt content of the diet.

In an experiment during 1942, three groups of 24 chicks each were placed on a diet containing no animal protein. One group received 1 per cent of salt, another 0.5 per cent, and the third no salt. The birds without salt did not thrive and many died during the fifth and sixth weeks, yet neither they nor those on the other two levels of salt resorted to picking. Two years previously, however, in an experiment comparing salt levels of 2, 4, 6 and 8 per cent in a diet containing dried buttermilk, picking occurred even on the 8 per cent level.

These results indicate that increasing the salt content of bobwhite diets is of doubtful value as a preventative for picking and cannot be considered a certain cure for all cases of the habit. In two cases out of three, however, the addition of 1 or 2 per cent of salt to the feed for a few days should be efficacious in checking the trouble.

EFFECT OF DIETARY PROTEIN LEVEL

Nestler, Bailey and McClure (1942) in studies on the protein needs of bobwhite quail, in four experiments conducted during 1939, had more trouble consistently with picking on the lowest level of protein under consideration (22%) than on levels of 24 to 32 per cent.

PALATABILITY OF DIET

An unpalatable diet, as judged by feed consumption, seems to be related to picking. In six experiments involving seemingly unpalatable diets, the unrelished feeds, with one exception, tended to cause picking. Four experiments studied the fiber requirements of quail. Ground pearled hominy was the sole cereal and alfalfa meal or ground wood pulp the fiber. The diets were carefully balanced for the vitamin, mineral and protein needs by use of dried brewers' yeast, vitamin A and D feeding oil, bonemeal, limestone, salt, and a good source of animal protein. Consumption of these diets, however, regardless of the level of fiber, was much lower than of diets based on ground corn—and picking was very serious. It was severe also on two experiments comparing various protein concentrates (Table 1). The outbreaks were especially violent on diets containing as the sole protein, respectively, 56 per cent cottonseed oil meal, 49 per cent peanut oil meal, 48 per cent soybean oil meal, 27.3 per cent soybean oil meal with 27.3 per cent linseed oil meal, 38 per cent soybean oil meal with 9 per cent meat and bone scrap, and 37 per cent soybean oil meal with 9 per cent meat meal.

Some picking occurred on diets including soybean meal and fish meal, but those outbreaks were controlled more easily than in the other diets.

POSSIBLE MANAGERIAL CAUSES

Ewing (1941; pp. 201–202) lists many "contributing factors for cannibalism," such as crowding, inadequate eating and drinking space, idleness, too much heat, not enough air, etc. Ill effects of crowding are emphasized also by Titus (1941).

FLOOR SPACE

The experience of workers at the Patuxent Refuge, with quail raised on hardware cloth, shows crowding apparently not to be a factor. Nestler and Bailey (1941) allowed a maximum of 40 quail chicks for a brooding shelter (Coleman type) of 24×36 inches with sun porch of 72×36 inches. Thus the minimum per chick was 21.6 sq. in. of shelter and 64.8 sq. in. of sun porch, a total of 86.4 sq. in. Domestic chicks, by comparison, are at least ten times larger than quail at hatching time and Jull (1938) recommends a minimum of 50 sq. ft. floor space per 100 chicks or 72 sq. in. per chick.

In 1940 the quail on the Patuxent Refuge were kept in battery brooders for the first week and then moved to Coleman brooders. During 1941 the period in the battery was increased to two weeks and in 1942 to three weeks. Again 40 quail were considered the maximum number per battery unit of 35×23 inches, or one per 20 sq. in. Jull allows a minimum of 20 sq. in. of battery space for domestic chicks up to five weeks of age. On the Patuxent Refuge the number of quail has seldom exceeded 35 per battery unit, yet picking occurs. The trouble also has developed in battery units with only 18 chicks. On the other hand, an experiment started with 560 chicks during the hot month of August 1942 had only one victim of picking, despite the fact that each chick was allowed only 23 sq. in. of floor space during the first three weeks.

Of the 42 chick experiments, comprising 11,806 quail, conducted at the Patuxent Refuge during 1939–1943, 25 had less than 10 per cent of the chicks as victims of picking, even though three-fourths of this number were confined on less than 40 sq. in. of floor space per chick during the first week, and over half had less than this area during the second week. Of the remaining 17 experiments where picking affected 10 to 32 per cent of the chicks, 41 per cent had 40 sq. in. or more of floor space per chick during the first week, and 53 per cent had this greater area during the second week.

Among adult quail, severe picking has occurred in pens with as much as 8 and 9 sq. ft. of floor space per bird and also with an adequate supply of water and wholesome food.

FEEDING AND DRINKING SPACE

Increasing the feeding space seems to have a noticeable and beneficial effect on growing quail. During 1939 to 1941, one flat feeding tray 4×9 inches placed inside a slightly larger waste tray was used in each brooder pen for the first two weeks of brooding, giving 1.3 to 2.2 sq. in. of feeding space per bird. Likewise there was only one watering device, a tin can 2.5 inches in diameter inverted into a coaster 3.5 inches in diameter. During 1939 the chicks were fed on the tray until large enough (at the end of about four weeks) to use

adult wall feeders by standing on a wooden step. During the following year an attempt to substitute after the fifth day an intermediate wall feeder 18×1 ×1 inches for the tray ended in failure, as the birds could or would not use this feeder. It was left as an addition to the tray but finally discarded entirely.

In a special home-made brooder, several "cafeteria" studies were conducted in 1941. For 36 to 55 chicks there were 8 to 11 feed trays and 4 drinking places. The mortality was noticeably lower than in the other pens and picking was eliminated. The same results were obtained on a single diet instead of several. During seven tests in the home-made brooder involving 250 chicks, only two birds were picked.

As a result of this clue, two feeders instead of one were placed in each battery unit for the last experiment during 1941. Only 10.7 per cent of the birds were picked as compared with 28.5 and 32.0 per cent, respectively, of those in two other experiments using similar diets where other conditions were the same except for the number of feeding dishes.

During 1942 and 1943, two waterers and two feed trays were placed in each battery unit and, at the end of two weeks, two new intermediate wall feeders, 18×2×1.5 inches, were introduced. The latter were well accepted by the birds.

A fourth change occurred by chance at the same time. New coasters were purchased to replace broken ones. The only ones available were 4 instead of 3.5 inches in diameter at the top, giving the birds 0.25 inch additional drinking space around the can. In units where both sizes were tried, the smaller was ignored by the birds. As soon as preference for the larger coasters was substantiated, the latter were used exclusively.

Of the 25 experiments where less than 10 per cent of the chicks were picked, 19 had two or more feeders and two or more waterers per pen, an average of one of each for 12 chicks. Thirteen of these had the larger coasters and the 2 inch wall-feeder after the second week. Of the 17 experiments where picking affected from 10 to 32 per cent of the chicks, 15 had only one feeder and one water container for a pen averaging 38 chicks.

FROSTBITE

Adult quail on wire sometimes have their feet frostbitten and resort to self-picking, apparently to alleviate the resulting irritation. Two such outbreaks have occurred in our experience. Skin peeled from some toes and cracks developed over the instep. The birds lacerated their own feet at the points of irritation until they were unable to walk. Application of iodine to the injured parts and the clipping of beaks alleviated the condition. Some quail propagators prevent frostbite during the cold months by spreading a layer of loblolly pine needles or wheat straw on the wire of the sun porch.

REDUCED PICKING

The incidence of picking (Table 2) has been significantly lower at the Patuxent Refuge during 1942 and 1943 as compared with the three previous years. During the earlier period, 16 per cent of 6,044 chicks were injured by picking, three-fourths of them during the first two weeks of brooding. Eighty-four per cent of the picked birds died, but whether from this injury

TABLE 2.—INCIDENCE OF PICKING AMONG BOBWHITE QUAIL AT THE PATUXENT RESEARCH REFUGE.

	High incidence			Low incidence		Totals
	1939	1940	1941	1942	1943	
Totals on experiment	816	1,704	3,524	3,840	1,922	11,806
Picked during 1st and 2nd weeks:						
Numbers	90	157	481	52	13	793
Percentages	*11.0*	*9.2*	*13.6*	*1.4*	*0.7*	*6.7*
Picked during entire experiment:						
Numbers	120	229	619	167	109	1,244
Percentages	*14.7*	*13.4*	*17.6*	*4.3*	*5.7*	*10.5*
Picked chicks that died during experiment:						
Numbers	119	214	482	81	59	955
Percentages	*99.2*	*93.4*	*77.9*	*48.5*	*54.1*	*80.9*

alone or from a combination of causes could not be ascertained in most cases. On the other hand, during 1942 and 1943, only 4.8 per cent of 5,762 quail were injured by picking; less than one-fourth of the cases occurred during the first and second weeks and of these only slightly more than 50 per cent died.

CONCLUSIONS

Except in cases of self-picking following irritation or injury to the feet, picking apparently originates as a "nervous" condition of one or a few birds that chafe at confinement or are naturally vicious; the habit seemingly affords an outlet for their nervousness. Less nervous pen mates may be led to take up the vicious habit, hence prompt removal of the offending birds from a pen is very important.

Several avoidable conditions may accentuate the picking habit. Its complete eradication among pen-reared quail may be impossible, but apparently can be minimized by the following practices:

1. A palatable, well-balanced game-bird mash should be fed. For young birds the diet should contain about 28 per cent of crude protein. If meal is used instead of pellets, the grain portion should be granular, as if ground in a hammer mill with a 3/32 inch mesh screen.

2. Adequate feeding and drinking space is needed. Several feed and water containers are better than one of each, and they should be constructed to permit easy accessibility.

3. Monotony in the diet should be relieved by an occasional serving of chopped greens. Increasing the salt content for a short time or supplementing the regular diet with a tray of some different feed for several days will give similar results. Salt alone is of little or a no value as a preventative, but adding 1 or 2 per cent of salt to the feed for a day or two is effective in two-thirds of the cases.

4. The beaks and toenails of birds on wire floors are not worn down as with quail on the ground, hence they should be trimmed with scissors, especially if the birds are to be held over the winter.

5. Covering part of the wire floor in maintenance pens with long pine

needles or wheat straw will help to prevent frost-bitten feet, a condition that may lead to self-picking.

6. Pickers should be removed promptly.

SUMMARY

During five years (1939–43) of nutritional research on pen-reared bobwhite quail at the Patuxent Research Refuge, Bowie, Maryland, observations on picking among birds of all ages showed the following results:

1. Picking occurred on all grains tested: corn, wheat, oats, oat groats, barley, millet, buckwheat, kaffir, and mixtures of cereals. The lowest incidence was with buckwheat as the sole grain in a growing diet.

2. Picking occurred on all levels of fiber from one to 11 per cent in a growing diet.

3. Picking occurred on various grinds of corn, barley, and oats, but was least when these cereals were ground in a hammer mill with 3/32 inch mesh screen.

4. The incidence was as high on diets containing animal protein as on those containing no animal protein.

5. After picking began, the addition of one or two per cent of salt to the diet for several days was effective, in many instances, in checking the disorder. Results at the Refuge and the answers to questionnaires from 222 private propagators of gamebirds showed that in two-thirds of the cases, treatment with an increased quantity of salt successfully stopped the trouble. As a preventative, however, salt was of little value. Picking occurred on both low and high levels of salt.

6. Supplementing the regular diet with certain feed concentrates such as fish meal, soybean oil meal, liver meal, or chopped greens offered in a separate feeder for a day or two, was as efficacious as the addition of salt.

7. More picking occurred among quail chicks on a 22 per cent level of protein than on higher levels.

8. There was less picking on diets relished by the birds than on those seemingly unpalatable.

9. There was no correlation between the amount of floor space per chick and the incidence of picking.

10. Increasing the feeding and drinking space seemed to have a marked beneficial effect.

11. Some adult birds on wire floors resorted to self-picking of their feet after the toes were frost-bitten.

LITERATURE CITED

BASS, C. C. 1939a. A practical remedy for the "nose-picking" form of cannibalism in young quail in close confinement. Maryland Conservationist, **16**(3).

1939b. Control of "nose-picking" form of cannibalism in young closely confined quail fed raw meat. Soc. Exp. Biol. and Med. Proc., **40**: 488–489.

BEARSE, G. E., V. L. MILLER and C. F. MCCLARY. 1938–39. The effect of various types of fiber and bulk on cannibalism. Western Washington Agric. Exp. Sta., Ann. Rept.

1940. The cannibalism preventing properties of the fiber fraction of oat hulls. Poultry Science, **19**: 210–215.

EWING, W. R. 1941. Handbook of poultry nutrition. Upper Montclair, New Jersey, W. R. Ewing.

HALPIN, J. G., and C. E. HOLMES. 1941. Salt prevents some types of cannibalism. Univ. Wisconsin Bul., **451**.

HANDLEY, C. O. 1931. The food and feeding habits of bobwhites, *in* H. L. Stoddard, "The Bobwhite Quail." New York, Chas. Scribner's Sons, pp. 113–157, 159–165.

JULL, M. A. 1938. Poultry husbandry, 2d ed. New York, McGraw-Hill Book Co. 548 pp., illus.

KENNARD, D. C., and V. D. CHAMBERLAIN. 1936. Oats for chickens. Ohio Agric. Exp. Sta. Bi-monthly Bul., 21(181): 95–97.

NESTLER, R. B. 1941. Common salt as a curative for cannibalism among game birds in captivity. U. S. Fish and Wildlife Service, Wildl. Leaflet, BS 163, 2 pp.

1943. Effect of large quantities of common salt in the diet of bobwhite quail. Journ. Wildl. Mgt., 7: 418–419.

NESTLER, R. B., and W. W. BAILEY. 1941. Bobwhite quail propagation. U. S. Fish and Wildlife Serv., Conserv. Bul., 10, 50 pp., illus.

NESTLER, R. B., W. W. BAILEY and H. E. MCCLURE. 1942. Protein requirements of bobwhite quail chicks for survival, growth, and efficiency of feed utilization. Journ. Wildl. Mgt., 6: 185–193.

NEWMAN, TOM. 1935. Cannibalism (a year of discovery on the experimental farm). Eggs, 33(17, suppl.): 4, 5.

PRENTICE, J. H. 1933a. The role of salt in poultry nutrition (1) Salt in the nutrition of the chick. N. Ireland, Journ. Ministry Agr., 4: 72–91.

1933b. The role of salt in poultry nutrition (2) Salt in the nutrition of the laying hen. N. Ireland, Journ. Ministry Agr., 4: 92–104.

TITUS, H. W. 1941. The scientific feeding of chickens. Danville, Ill., The Interstate. 116 pp.

VALUE OF WILD FEEDSTUFFS FOR PEN-REARED BOBWHITE QUAIL IN WINTER[1]

Ralph B. Nestler, W. W. Bailey, A. C. Martin, and H. E. McClure

U. S. Fish and Wildlife Service and U. S. Bureau of Animal Industry, Washington, D. C.

The bobwhite quail (*Colinus virginianus*) is primarily herbivorous. According to Handley (1931) in studies with the Cooperative Quail Investigation, plant foods formed over 85 per cent of the average monthly diet of adults and more than half the total in every month, the greatest proportion (97.8%) being consumed in February.

Although some green leaves and other plant parts are consumed at times, the bobwhite feeds preeminently on seeds and fruits; those utilized comprise many kinds of wild and cultivated legumes, various grasses including cultivated cereals, woody plants (mast) particularly pines and oaks, as well as spurges, sedges, and others. The wild food materials used in the present investigations are, with few exceptions (*Diodia, Myrica, Rhus*), recognized as important elements of the bobwhite's natural diet.

Through the cooperation of the Soil Conservation Service, Forest Service, Refuge Division of the Fish and Wildlife Service, and the Cooperative Wildlife Research Units, large quantities of miscellaneous plant foods utilized by bobwhites were obtained during the autumn of 1939 for chemical analysis, and for research upon their palatability, digestibility, and comparative feeding value for adults maintained through the winter. The two experiments here reported are the first in

[1] Based on joint investigations by the Fish and Wildlife Service, U. S. Department of the Interior, and the Bureau of Animal Industry, U. S. Department of Agriculture, under funds provided by the Bankhead-Jones Act.

which extensive chemical analyses of wild foods have been combined with biological and nutritional studies on quail.

PROCEDURE

Experiment I was conducted for 20 weeks throughout the winter of 1939–40. On November 3, 264 quail of the 1939 hatch were placed in 12 maintenance pens, 22 birds in each. These birds were from experimental groups representing five different ages (12, 14, 16, 18, and 20 weeks) and their distribution was on the basis of age as well as sex and weight, so that all pens would be comparable. For the first 28 days, all were given Control Diet A, as follows (parts by weight):

MASH	
Yellow corn, ground	26.4
Oat groats, ground	10.0
Wheat, ground	10.0
Alfalfa leaf meal	10.0
Fish meal, North Atlantic	19.0
Soybean oil meal	7.0
Peanut oil meal	5.0
Dried buttermilk	10.0
Limestone, ground	1.0
Salt mixture I	1.0
Cod liver oil, fortified	0.6
GRAIN MIXTURE	
Yellow corn, cracked	40.0
Wheat, whole	20.0
Kaffir corn, whole	20.0
Oat groats	20.0

Salt Mixture I comprised sodium chloride, 5,000.0 parts, and manganous sulfate tetrahydrate, 406.15 parts.

After the initial 4-week period, the diets given in Table 1 were fed; then Control Diet A was used in conjunction with Control Diet B, which was as follows:

Yellow corn, ground	34
Wheat, ground	17
Kaffir corn, ground	17
Oat groats, ground	17
Mammoth yellow soybeans, ground	13
Alfalfa leaf meal	2

Experiment II was conducted for 14 weeks through the winter of 1940–41. During November, 192 bobwhite quail were distributed into 12 maintenance pens, 16 birds per pen, those in each being comparable as to weight, sex, and age. The birds were changed directly from a regular maintenance mash to the experimental diets listed in Table 1. Control Diet C and Basal Diet D were as follows (parts by weight):

	Diet C	Diet D
Yellow corn, ground	92.0	92.0
Alfalfa leaf meal, dehydrated	5.0	10.0
Salt mixture II	2.0	4.0
Bonemeal, special stamed	1.0	2.0

Salt mixture II included sodium chloride, 5,000.0; manganous sulfate, anhydrous, 42.5; ferrous sulfate, anhydrous, 27.5; copper sulfate, anhydrous, 0.5; and potassium iodide, 0.5 parts by weight.

The chemical analyses of the wild feedstuffs (King and McClure, 1944) show that seeds of the loblolly pine and seeds or fruits of buttonweed, ragweed, smooth sumac, wax myrtle, and bayberry are high in fiber content. The crude protein content of those foods and of bullgrass and acorns, however, is low; that in the seeds of all the legumes is high, as expected. The birds and the feed residues, in both experiments, were weighed every four weeks.

RESULTS

MORTALITY AND GENERAL CONDITION

There was no mortality in most of the pens. Of the 21 deaths, 15 (71%) resulted from picking or fighting, one bird showed cecitis, another had enterohepatitis, and four died of unknown causes. The highest mortality (4 birds,

TABLE 1.—EXPERIMENTAL DIETS ON WILD FEEDSTUFFS WITH BOBWHITE QUAIL.

Pen no.	Diet[a]	Percentage composition		
		Crude protein	Fat	Fiber
	EXPERIMENT I			
1, 2	Control A[b]	27.74	4.78	5.08
3	Control B	15.29	5.28	2.63
	Mixture; Control B (50%) and the following ground seed (50%).			
4	Trailing wildbean	21.62	3.12	6.80
5	Crabgrass	13.94	4.32	7.39
6	Bullgrass	11.04	4.35	9.01
7	Water oak, including hull (no analysis)	—	—	—
8	Common lespedeza	27.77	6.17	6.90
9	Black locust	28.20	8.35	8.42
10	Common ragweed	20.20	12.99	13.52
11, 12	Cafeteria A (no analysis)	—	—	—
	EXPERIMENT II			
13	Control C	9.04	3.45	2.62
	Mixture of Control D (50%) and the following ground seed or fruit (50%)			
14	Buttonweed	10.17	4.16	19.65
15	Loblolly pine	12.58	6.26	21.49
16	Partridge pea	19.09	4.48	5.12
17	Panic grass	11.23	4.24	8.15
18	Smooth sumac fruit, pulp or skins	7.69	8.70	13.91
19	Sweetgum	14.78	8.02	13.24
20	Willow oak	8.32	10.91	8.18
21	Korean lespedeza	22.21	5.86	6.13
22	Bayberry and wax myrtle	8.44	10.38	18.15
23	Crabgrass	12.09	3.63	8.08
24	Cafeteria B	14.60	7.13	7.76

[a] Beginning Jan. 8, a feeder containing ground oyster shell, 4 parts, and common salt, 1 part, was placed in each pen.
[b] Mash only of Control Diet A was analyzed.

or 25%) and the most serious outbreaks of picking in any pen occurred on the diet containing equal parts of bayberry and wax myrtle fruits. There was no noticeable difference in the appearance of the birds on the various diets, except that those on the mash containing 50 per cent of smooth sumac skins developed a severe neck moult at the end of eight weeks. Details on the food value of sumac fruit have been reported by Nestler and Bailey (1944).

WEIGHTS OF BIRDS

On all diets, the quail showed marked increase in weight during the forepart of the winter, through January. All weights declined during February. When the experiments ended those on Control Diet A showed no increase over their initial weights. The least gains (1 to 2%) were by birds on Control Diets B and C, one lot on Cafeteria A, and those on the diet containing water oak acorns. The greatest gains (11–13%) were seen in birds on Cafeteria B, and the diets containing, respectively, sumac skins, willow oak acorns, and the mixture of equal parts of bayberry and wax myrtle fruit. The bobwhites on the diet containing wildbean seeds showed a 9 per cent gain in weight. All of the

remaining birds on the two experiments weighed 4 to 7 per cent more at the close of the studies than at the start.

FEED CONSUMPTION

The differences between the quantities of the various diets consumed (Table 2) are highly significant according to Fisher's t test for statistical significance. There was no correlation between the gains or losses in bird weights and their consumption of feed.

TABLE 2.—FEED CONSUMED PER BIRD PER DAY.

Diet	*Grams*
EXPERIMENT I	
Control A, Lot I	16.7
Lot II	18.3
Cafeteria A, Lot I	16.3
Lot II	15.2
Control B	14.7
Mixture of Control B (50%) and the following ground seed (50%):	
Trailing wildbean	16.5
Crabgrass	15.8
Bullgrass	17.3
Water oak	14.5
Common lespedeza	16.5
Black locust	14.6
Common ragweed	15.5
Standard error	*±0.61*
EXPERIMENT II	
Control C	14.5
Cafeteria B	13.5
Control D (50%) +ground seed or fruit (50%).	
Buttonweed	18.8
Loblolly pine	18.6
Partridge pea	15.4
Panic grass	15.9
Smooth sumac (skins)	17.7
Sweetgum	15.0
Willow oak	14.0
Korean lespedeza	15.3
Bayberry and wax myrtle (1:1)	17.3
Crabgrass	15.8
Standard error	*±0.47*

Cafeteria A of Experiment I offered a free choice of the various whole wild seeds used in that experiment, and also yellow corn. Whole kernels of corn and entire acorns were fed only for the first two weeks in the "cafeteria" pens. The birds tried to use such large seeds, but generally lost them through the wire-mesh flooring after mulling them in their beaks for several seconds. Waste was practically eliminated when the entire seeds were replaced with cracked materials.

The preferences of the quail for the various feedstuffs are shown in Table 3. In Experiment I cracked yellow corn and ragweed seed rivalled for first choice. Of the wild feedstuffs, ragweed was the most popular by a wide margin, nearly twice as much being consumed as of locust seed and four to six times as much as of common lespedeza.

Cafeteria B of Experiment II was a free choice of the wild seeds used in that experiment; these were unground except for cracked acorns and cracked yellow corn, alfalfa leaf meal, common salt, and cracked oyster shell. Crimson clover, Chinese lespedeza, shrub lespedeza, and Augusta vetch were added near the end of the experiment.

Cracked yellow corn was outstandingly the favorite food, more than 50 per cent being used in the diet. For the eight weeks ending January 29, Korean lespedeza was preferred over the other nine wild feedstuffs. Cracked acorns of the willow oak made up nearly 9 per cent of the diet, whereas loblolly pine mast and buttonweed seed were scarcely touched. From the beginning of the "cafeteria" feeding, the quail separated the fruits of bayberry from those of the wax myrtle, discarding the former and consuming the latter; hence the figures for "mixture of bayberry and wax myrtle" (Table 3) apply mainly to wax myrtle.

TABLE 3.—FEEDSTUFFS SELECTED BY BOBWHITE QUAIL WHEN GIVEN A WIDE CHOICE. (all figures are percentages)

Feedstuffs (seeds or fruits)	Experiment I		Experiment II		
	Dec. 1–Mar. 22		Dec. 4–Jan. 29	Jan. 30–Feb. 12[a]	Feb. 13–Mar. 12[b]
	Lot I	Lot II			
Corn, yellow, cracked	28.8	29.5	56.1	68.3	55.4
Trees and shrubs:					
Oak, water (cracked)	3.5	3.3	—	—	—
Oak, willow (cracked)	—	—	8.9	3.9	2.9
Pine, loblolly	—	—	0.5	0.5	0.3
Sweetgum	—	—	2.8	3.2	9.6
Locust, black	16.7	15.0	—	—	—
Sumac, smooth (whole fruit)	—	—	2.4	0.8	1.2
Bayberry-wax myrtle mixture	—	—	1.3	2.7	0.3
Legumes:					
Lespedeza, common	5.2	7.3	—	—	—
Korean	—	—	14.7	5.2	0.6
Shrub	—	—	—	—	19.8
Chinese or sericea	—	—	—	—	1.0
Wildbean, trailing	4.6	2.9	—	—	—
Clover, crimson	—	—	—	4.7	0.5
Vetch, Augusta	—	—	—	—	0.3
Partridge pea	—	—	2.5	1.5	0.8
Grasses:					
Crabgrass	3.5	4.9	3.2	2.3	1.9
Panic grass	—	—	5.7	3.9	2.3
Bullgrass	7.0	8.6	—	—	—
Miscellaneous weeds:					
Button weed	—	—	0.3	0.0	0.3
Ragweed, common	30.7	28.5	—	—	—
Other feedstuffs:					
Alfalfa leaf meal	—	—	1.0	0.5	0.5
Oyster shell grits	—	—	0.5	2.1	1.4
Salt, common	—	—	0.1	0.4	0.9

[a] Crimson clover added.
[b] Shrub lespedeza, Chinese lespedeza, and vetch added.

When crimson clover seed was added to the cafeteria in Experiment II, the quail ate it as readily as the seed of Korean lespedeza. When the seeds of shrub lespedeza, Chinese (sericea) lespedeza, and narrowleaf vetch were included, clover and Korean lespedeza were rejected and shrub lespedeza became the preferred wild food, composing nearly 20 per cent of the diet. The consumption of Chinese (sericea) lespedeza, vetch, and partridge-pea was low, only one per cent or less of each in the diet. The role of sweetgum seed in the diet became more prominent during the four weeks ending March 12, when its consumption trebled that in the forepart of the experiment.

A combination of the various feedstuffs, in proportions approximating the selection made by the quail, when analyzed, showed a percentage com-

position as follows: water, 8.9; crude protein, 14.6; ash, 2.8; fat, 7.1; fiber, 7.8; nitrogen free extract, 59.0; calcium, 0.51; and phosphorus, 0.32.

Several factors should be considered in evaluating these results. (1) The quail were pen-reared on a mash of commercial feedstuffs from hatching until the start of the studies, hence were completely unacquainted with entire wild foods. (2) The feedstuffs remained dry and ungerminated, instead of being subjected to weathering as under natural conditions. This may have had considerable effect on the acceptability of certain seeds. Nestler (1943) found quail to show a decided preference for germinated wild beans over ungerminated seed, but with Korean lespedeza they tended to prefer the ungerminated seed. (3) A plentiful supply of each feedstuff was provided at all times in a separate hopper, but all were in close proximity; there is no analogous condition in the wild. (4) The birds lived on wire floors (3 meshes per inch) through which many of the larger seeds dropped out of reach; under natural conditions most of these seeds might have been recovered and finally consumed.

SUMMARY

1. During the winters of 1939–40 and 1940–41, two experiments involving 456 bobwhite quail, were conducted at the Patuxent Research Refuge, Bowie, Maryland, to determine the palatability and comparative feeding value of 20 common wild quail-foods when offered as a part of a maintenance diet.

2. Mortality was low on all diets, the highest occurring on that containing a mixture of bayberry and wax myrtle fruits. On all diets the birds showed increases in weight during the early winter. These gains were better maintained by birds on the wild foods than those on control diets composed entirely of cultivated feedstuffs.

3. There were statistically significant differences between the quantities of the various diets eaten.

4. For palatability and acceptability, seeds of common ragweed (*Ambrosia artemisiifolia*) and of shrub lespedeza (*Lespedeza bicolor*) were the preferred wild foods.

5. It is concluded that pen-reared bobwhite quail can be maintained successfully through winters in the vicinity of Washington, D. C., on diets containing 50 per cent of any one of the wild foods listed and 50 per cent of a high-caloric commercial seed mixture with yellow corn as the principal cereal.

6. The results of these "cafeteria" studies, although interesting and indicative of the preferences of quail in confinement, do not necessarily represent selections that might be made by bobwhites in the wild.

LITERATURE CITED

HANDLEY, C. O. 1931. The food and feeding habits of bobwhites, *in* H. L. Stoddard, "The bobwhite quail, its habits, preservation, and increase." New York, Chas. Scribner's Sons. 559 pp., illus.

KING, T. A., and H. E. MCCLURE. 1944. The chemical composition of some American wild feedstuffs. Journ. Agric. Research, 69: 33–46.

NESTLER, R. B. 1943. Germinated seed versus ungerminated seed in the diet of adult bobwhite quail. Poultry Science, 22: 227–229.

NESTLER, R. B., and W. W. BAILEY. 1944. Sumac fruit as a food for bobwhite quail. Amer. Midland Naturalist, 31: 689–696.

QUADRAT INVENTORY OF PHEASANT TRENDS IN OREGON[1]

Arthur S. Einarsen
Oregon Cooperative Wildlife Research Unit, Corvallis, Oregon

A few bronze-breasted cocks of the ring-necked pheasant (*Phasianus colchicus torquatus*) strutting the roadside fields and meadows in spring often bring visions of abundance to sportsmen, who plead for more liberal bag limits and longer seasons. Unfortunately, few states have scientific methods available to measure practically the abundance and the population trends of upland game birds. Correlation has been lacking between popular ideas as to quantity and scientific findings based upon field investigations. To solve this problem, a study was made to develop practical census methods for the layman and to help improve the practices of management officials.

Fluctuations in wildlife populations often are apparent, but general trends are difficult to determine. Complete confidence in a census record is rare, even in the mind of the census-taker. Since individuals of most wild species are secretive and wide-ranging, it is erroneous to assume that successive censuses made on the same land area will encounter identical birds.

This applies especially to ring-necked pheasants whose active feet and wings permit them to cover wide stretches of territory in a day. Pen-reared pheasants, banded and released near Corvallis during November 1937, were recovered the following day 6 miles from the liberation point. Sixty per cent of the banded pheasants recovered in western Oregon ranged annually within a radius of 3 miles of where released. Further studies of naturally-reared banded birds, with which little experimental work has been done, may alter these figures.

It is obvious that a method to measure trends by correlating a population with its habitat acreage is more practical than attempts to count every bird. Research on this subject was started by the Oregon Cooperative Wildlife Research Unit in 1937. It was soon apparent that the straight line census was inefficient, since field workers wasted half of their time walking back to their automobiles before driving to a new area. Such a census also is unwieldy, as a representative cross-section of pheasant habitat can rarely be obtained on a straight line less than 2 miles in length. Likewise, roadside counts and direct census drives were not practical in Oregon because of the scarcity of both roads and field investigators.

Experiments with several possible census methods led to a plan whereby an observer walks the perimeter of a square or rectangle on pheasant range and records pertinent data. By trial and error a few basic methods were evolved. These have been augmented by scientific sampling and correlations until a practical field method can now be offered. Upon the advice of statisticians, mathematical formulae have

[1] United States Fish and Wildlife Service, Oregon Agricultural Experiment Station, Oregon State Game Commission, American Wildlife Institute, and Agricultural Research Foundation, cooperating.

not been used because of the number of unknown quantities. Subsequent experiments may result in improvements in accuracy or adaptability.

The quadrat system has been used in Oregon for six years and has been the basis for management which increased the pheasant population from 1.3 to 45 birds per 100 acres in the Willamette Valley. It is submitted as a method for use in other pheasant and upland game areas *only after adjustments have been made in its application to fit local conditions.*

PRINCIPLES OF INVENTORY MAPPING

The Traffic Station maps of the Oregon Highway Commission were found to be most suitable for recording data and laying out quadrats. These combine information on roads and human population and permit easy orientation. A field record book con-

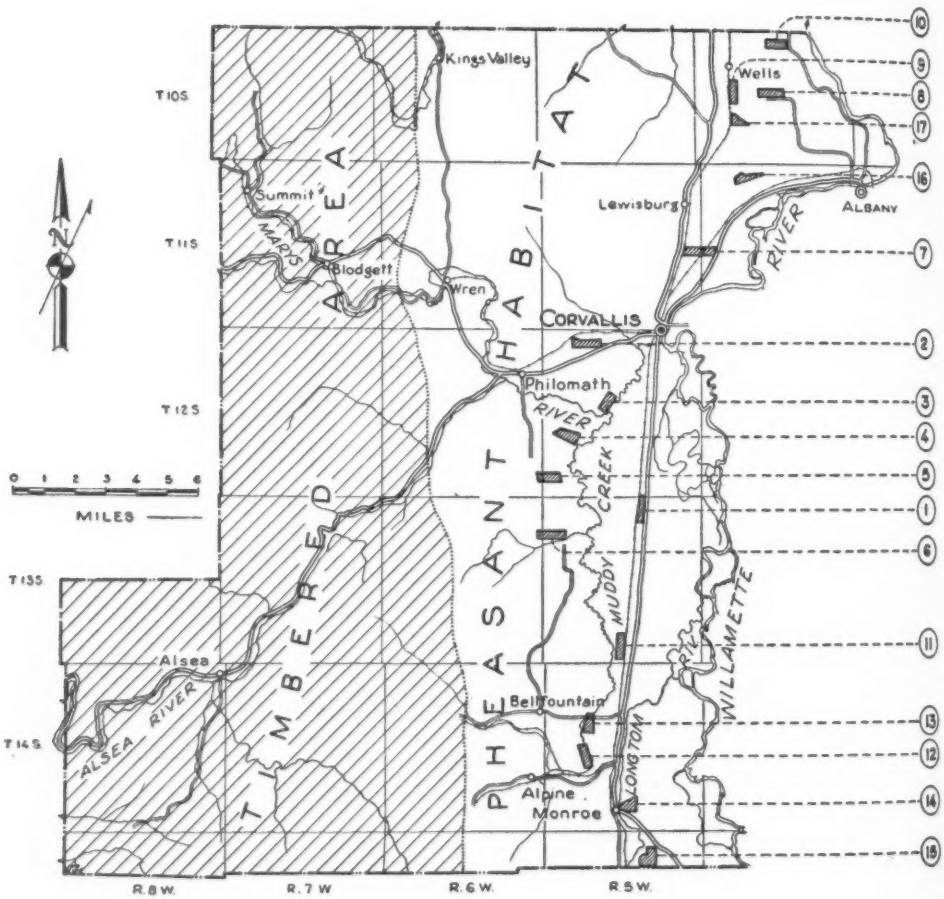


Fig. 1. Orientation map showing location of quadrats (shaded areas with numbers); a permanent record used by field workers to keep records of inventories of game species. Benton County, Oregon, 1940.

taining pertinent facts about each sample quadrat also is essential. The observer refers to the map for location, and the record book gives him additional information. Field record books should be kept up-to-date with complete information as to boundaries and

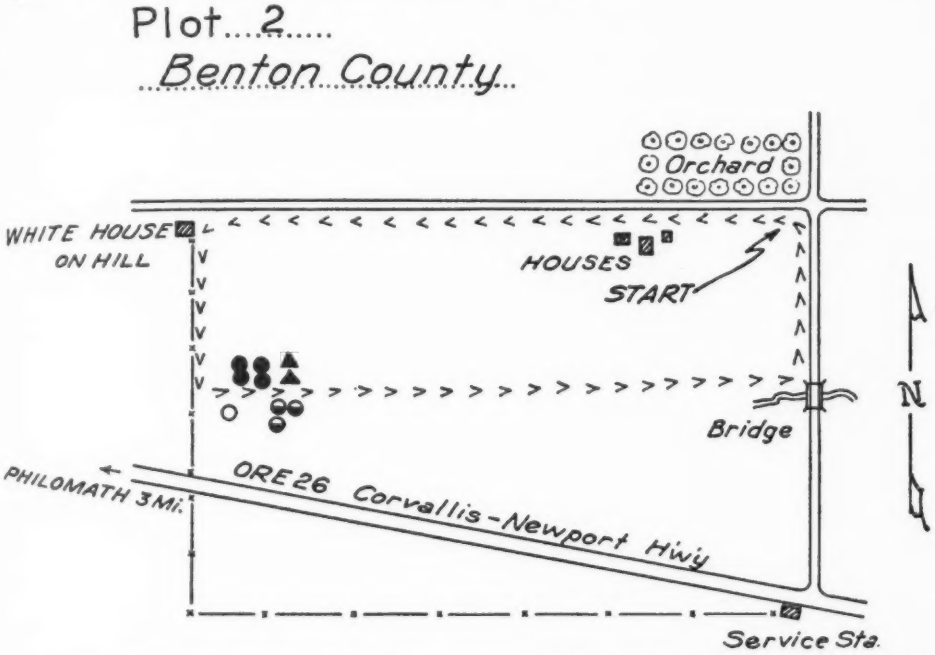


Fig. 2. Sketch map of Plot No. 2, Benton County, Oregon, showing features useful to the census worker for ease in location of census. Path of census, > >; male pheasants, ▲; female pheasants, ●; chicks, ◒.

outstanding landmarks, and the direction of the route to be taken (Figs. 1 and 2).

CHOOSING QUADRATS

After various tests, a quadrat 1 mile long by ¼ mile wide was deemed most suitable, both to determine abundance and to obtain an accurate cross-section of habitat. The field worker should know what constitutes upland game range, as the sample is not representative if it does not meet a few basic requirements. Some personal knowledge of the area is useful. Gross errors can result from consistent choice of either the best or poorest range if the game population is less than one bird per acre. Methods change when higher concentrations exist, as will be explained later (Fig. 3).

A quadrat entirely in an evergreen woodlot would not result in a true sample, since such an area is not ordinarily considered pheasant habitat. It is permissible to run one side through a woodlot where few birds are present, if, on the return trip, a fence row or other good cover is followed for a distance comparable to that on the woodlot (Fig. 3, *bottom*).

Flushing strips less than ¼ mile in width have proved inaccurate, especially if there is little ground cover such

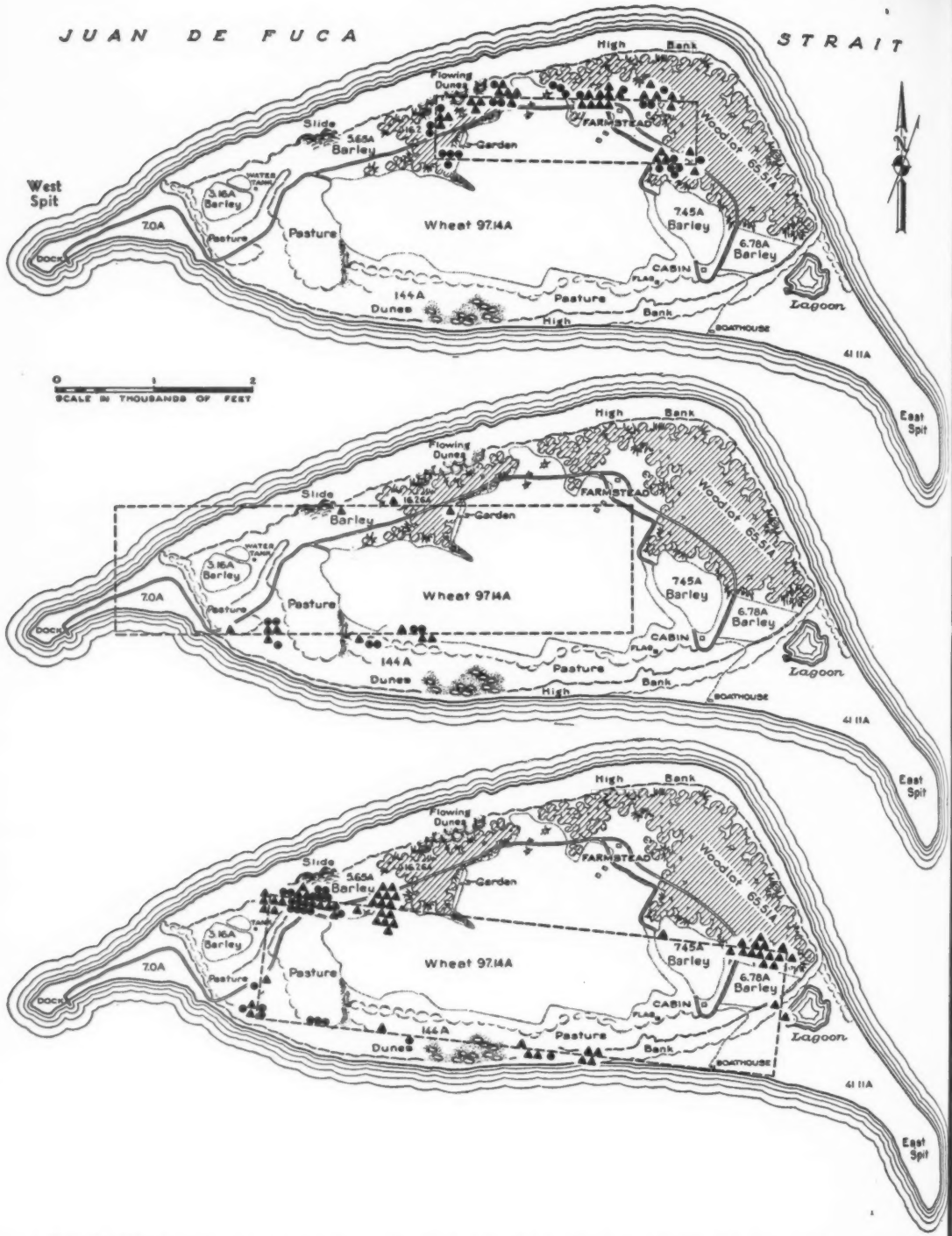


Fig. 3. Pheasant inventory quadrats, Project A-2, Protection Island, Washington. All counts made September 10, 1941, A.M., weather clear and calm; pheasants: male, ▲; female, ●.

Top. Quadrat No. 4. Effect of using small quadrat ($\frac{1}{8}$ by $\frac{1}{4}$ mile). Pheasants in open areas can be counted only on one side of a narrow quadrat, since those on opposite side will leave before observer arrives. *Center.* Quadrat No. 5. Poorly chosen, including too much open or unsuitable ground and not covering a fair sample of the habitat. One such area, however, in a good series of quadrats will produce only slight error. *Bottom.* Quadrat No. 8. Well chosen, including almost equal amounts of cover and of feeding ground.

as on newly-mown hay fields, cattle-worn stubble, or closely cropped pastures, where the birds will flush and depart from the area when the first long side of the quadrat is run, leaving none to enumerate on the return trip. A wider quadrat corrects this error.

A field worker unfamiliar with section and quarter-section lines may use a pedometer to measure distances so that the quadrats will be as uniform as possible. They need not be of uniform dimensions if a representative sample of habitat is taken. When inventories are made year after year it is more important to cover the same territory than to measure identical distances.

If information is desired as to the effect of changes in vegetation or agricultural practices on upland game, the same quadrats should be examined annually. When only population trends are sought, quadrats can be covered at random if in sufficient number.

CONDUCTING THE INVENTORY

After the quadrat is selected, the observer may start at any convenient point which is marked in the field record book. Walking at a gait slow enough to permit accurate observation, he scrutinizes carefully *a 100-foot strip on each side of the line of travel.* Small errors in judging the correct width of the strip prove unimportant after a little practice. Each bird is recorded in a notebook or on ruled heavy cards by symbols indicating the sex, age class (if possible), and location of each individual sighted or flushed from the 200-foot strip. Care must be taken not to record a running bird and then to enumerate it again when flushed.

On a newly-established quadrat, it is well to draw the four sides of the rectangle and roughly sketch all visible landmarks in the record book before making a count. As the observer progresses across the tract, he can add other distinguishing objects and record information deemed important for later use, either by himself or a subsequent worker. These may include game data, distance from water, proximity to crops, relation to shade, type of cover, and other details. The total acreage inventoried can be computed from the total perimeter walked (Table 1) by the following formula:

Perimeter in feet × 200 ÷ 43,560 = Acreage

The perimeter is determined by using a pedometer or measuring distances between sections or similar units.

The aim is to determine the number of birds per habitat acre, rather than the total bird population in a given area. A complete survey and classification of the ground covered would be necessary to ascertain the latter, but

TABLE 1.—ACREAGE INVENTORIED, BASED ON PERIMETER OF QUADRAT.

Perimeter	*Area inventoried (fractions omitted)*
1¾ miles	42 acres
1⅞	45
2	48
2⅛	51
2¼	54
2⅜	57
2½	60
2⅝	63
2¾	66
2⅞	69
3	72
3⅛	75
3¼	78
3⅜	81
3½	84
3⅝	87
3¾	90
3⅞	93
4	96
4⅛	99
4¼	103

such elaborate detail usually is not required for management purposes.

Quadrats should not be censused on night-roosting grounds before 8 a.m. during the seasons when use of the quadrat method has been most effective, as the night-time concentrations include birds from a wide area. Such grounds can be identified by the abundance of droppings around grass clumps and weed bunches. In the Willamette Valley, from September until March, most of the pheasants seek such roosting sites in preference to remaining where nightfall overtakes them.

From many observations it was found that in all types of cover, unless the pheasant population exceeded 100 birds per 100 acres, few were flushed farther than 100 feet on each side of the observer's course. This fixed the 200-foot strip previously mentioned.[2]

A few precautions are necessary if the records on densely-populated fields or refuge areas show as many as 100 birds per 100 acres. At this level of abundance it is difficult to determine densities precisely and to clear up any doubt a few test quadrats should be censused, using certain modifications. On Protection Island, Washington, an experimental area of the Oregon Research Unit, more accurate results were obtained under these circumstances if quadrats were located on the best habitat rather than on equal amounts of good and mediocre cover. Even when the returns indicate a population of one bird per acre, the method as described is still to be used; but if higher concentrations are indicated, the following modifications are necessary.

With an exceptionally high concentration, as of 387 pheasants per 100 acres on Protection Island in 1941, it proved necessary to enumerate all birds seen or flushed, without regard to the 200-foot strip. On most areas, complete counts are unnecessary, because pheasant populations rarely attain to such numbers, but for experimental or research work this more detailed knowledge may be useful.

A dog may be used to flush the birds, although there are wide differences in the effectiveness of different individual animals. With good bird dogs, repeated trials may increase their efficiency about 50 per cent, when the results from a quadrat with a total perimeter of 50 acres should be recorded as for 75 acres. Since the inventory method was developed for simplicity and general use, uniformity can best be obtained without using a dog.

Some basic points in using the quadrat census are as follows:

1. The field day should not begin before 8 a.m. Standard Time. This will allow the birds to leave their night roosts, which is especially important on wet or dull mornings.

2. On hot days it is best not to work between 11 a.m. and 2 p.m., when the birds are inactive.

3. Censusing four quadrats requires an average working day, but five are possible.

4. During the first wet and stormy days in autumn, upland game birds are difficult to flush, and inventories then are impractical. After a few days of inclement weather, the birds will again become active.

[2] Field investigators of the Iowa Cooperative Wildlife Research Unit (Quarterly Report, July, August and September, 1942) working in the corn belt found the effective flushing strip to be about 90 feet; the width will vary in different habitats, but can be established easily by trial.

5. Adults, especially hens, lie close on cloudy, windy days, and this should be allowed for in making records of the sexes.

6. In Oregon, the best inventory months are from August to December. Inventories in March and April are practical unless wet weather persists. In late spring and summer, when crops and other vegetation are tall, entry to most quadrats is difficult and the birds conceal themselves too well to be observed.

7. From 10 to 30 quadrats should be run annually in each geographical unit. It is well to choose at least one quadrat for each 20,000 acres of habitat area. Ten quadrats should indicate the trends on a study area of 5,000 to 20,000 acres. On small study areas the quadrats can be identical or may overlap, but one day should elapse between successive samplings. Units for measurement should not exceed 500,000 habitat acres. Pooling the data on larger units leads to obscuring increases or decreases of the birds on definite habitats, and data for smaller areas are more useful for management purposes.

8. Records for each species, by sexes, should be made and related to the quadrat by notebook entries, using suitable symbols to permit later analysis of the data. If desired, notes on crops, proximity to water, types of cover, and other factors can be added. The records made by the Oregon Cooperative Wildlife Research Unit have been unusually complete in such matters and have provided information that has influenced the pheasant stocking practices of the Oregon Game Department with excellent effect.

9. Quadrat records should be mailed to the headquarters office daily to safeguard against loss and to enable supervisors to keep in touch with field workers (Fig. 4).

TESTS FOR ACCURACY

Investigators realize the lack of adequate tests to check the accuracy of field procedures; two are important to measure reliably the game birds on a study area. There must be a definite unit of ground having natural boundaries to limit the drift or infiltration of other birds, and the same population of birds with their progeny must remain within the natural limits during the study period. Fortunately, the Oregon Research Unit had these requirements at Protection Island, with a known population on 394 acres of varied habitat. The small size of the area permitted accurate counts during the five-year period of study.

Quadrat inventories were applied periodically to the Island population by different observers who lacked familiarity with the plan and the results to be expected. This was intentional, to avoid any possibility of influencing the observers in their findings. Censuses were taken and comparisons made on 800 quadrats, with results as follows, in birds per 100 acres:

Spring census	*Quadrat method*	*Direct drive method*
1940	100.3	107.0
1941	160.0	170.0
1942	301.5	336.3

The three-year test showed close agreement between the two methods. The direct count was used as a check, as often as needed, but even on this small tract proved highly impractical because of the number of observers needed and the difficulty and cost of

Date: *Nov. 10, 1940*

Lane County

Quadrat	Species[a]	Males	Females	Young	Unclassified	Perimeter
No. 7	*C.P.* *B.W.*	*10* —	*7* —	— —	*3* *20*	*2¼ mi.*
No. 4	*C.P.*	*9*	*10*	—	—	*2½ mi.*
No. 12	*C.P.* *B.W.*	*10* —	*7* —	— —	*5* *20*	*2⅞ mi.*
No. 13	*C.P.*	*7*	*2*	—	*13*	*2¾ mi.*

Mail or wire address for tomorrow: *Oregon City, Gen. Del.*

John Smith
Signature

[a] C.P. = Ring-necked (China) pheasant; B.W. = bobwhite quail.

Fig. 4. Daily post card report of quadrat inventories to headquarters office.

transporting personnel. In most instances, only one person is needed for the quadrat method. A game department can detail field men to such work in connection with their regular duties, using liberation crews, biologists, and patrolmen. State-wide coverage thus is possible at little or no extra cost for labor. The direct cost averages about $55 per million habitat acres.

Many other wildlife species can be studied by the random quadrat inventory. Hungarian partridges are found in only 3 counties in the Willamette Valley, with probably less than 200 birds existing on 2,700,000 habitat acres. Each year these were reported in the census records, although the field workers had no prior knowledge of the location of such coveys.

The method also has proved valuable in another respect. Study of 180 quadrats in 1939, indicated 11 areas barren of upland game. The 1940 and 1941 records substantiated these findings on 7 of the original 11 quadrats. The initial evaluation was evidently correct and the land was accordingly classified as poor upland game habitat. This is often as important as finding areas of heavy concentration.

During the autumn of 1939 and 1940, 402 quadrats were inventoried in the Willamette Valley. A summary, by counties, yielded the following results in pheasants per 100 acres:

County	*1939*	*1940*
Benton	10.3	21.3
Clackamas	4.7	7.0
Columbia	11.0	12.0
Lane	23.0	28.5
Linn	22.4	22.9
Marion	14.1	17.2
Multnomah	3.2	8.4
Polk	20.6	17.4
Washington	4.2	4.3
Yamhill	5.6	8.0

No "yardstick" had been used previously, but these censuses showed pheasant populations in several counties to be in serious condition, as in Clackamas and Multnomah counties. The latter includes the city of Portland, with about 350,000 human inhabitants, and pheasants in that county had been hunted almost to the point of extermination during open seasons. The inventory indicated only remnants (3.2 per 100 acres) even after a closed season in 1939.

In most counties where the birds are unusually scarce, habitat deficiency, human interference, or other factors complicate good management. In the experience of the Research Unit, the quadrat inventory method has aided in locating and isolating these problem areas and thereby has served as a guide for game management procedures. These results alone justify its use.

It is apparent that there is a close correlation between the observations of an independent worker and Research Unit findings of approximately the same date as shown by those of John McKean, Oregon State Game Department, using the quadrat method after learning of its use by Research Unit observers. His records are given in Progress Report No. 6, Pittman-Robertson Project 6-R, Oregon. Results of inventories conducted separately by McKean and by workers of the Research Unit in eight Willamette Valley counties during the autumn of 1941 were as follows as to the numbers of pheasants per 100 acres:

County	*Independent Worker*	*Research Unit*
Benton	20.9	20.7
Clackamas	9.1	4.4
Columbia	8.5	6.9
Linn	41.7	45.2
Marion	14.3	13.0
Polk	9.1	17.1
Washington	6.0	2.9
Yamhill	8.0	7.7

The quadrat method proved effective in the autumn of 1943, when public demand for game meat resulted in pressure on the State Game Commission to allow longer seasons and larger bag limits. Pheasants appeared to be unusually plentiful in Malheur County and the Commission granted a 40-day season there, with an 18-bird possession limit, one hen for each day's limit of 6 birds, and 3 hens in possession. The Research Unit took censuses before and immediately following the shooting season. The first was made on 53 quadrats in pheasant habitat between October 9 and 15, 1943, and indicated 40 pheasants per 100 habitat acres—enough to provide plentiful shooting. The post-season inventory, December 13 to 16, almost three weeks after close of the hunting season, allowed ample time for the birds to return to their usual habitats. Several sample quadrats revealed 24.7 pheasants per 100 habitat acres, a reduction of over 30 per cent, not including winter losses or birds crippled during the hunting season which would probably amount to an additional 10 per cent.

The two censuses showed that the pheasant population would be reduced dangerously in a short time if such a hunting program were to continue; the practical value of the quadrat method in this instance was obvious. Definite information was obtained and submitted for consideration by the Game Commission in setting future seasons and bag limits.

This method also was tested April 29 to May 2, 1944, in South Dakota, the outstanding pheasant-producing state

of the nation. It showed that hunting practices had reduced the populations in certain areas. The sex ratios reflected hunting pressure. In the heavily hunted areas the ratio of cocks to hens during the mating season (when the sexes intermingle) fell as low as 100 to 64, whereas a practical ratio would be 100 cocks to 500 hens.

In all of the territory covered there were fewer hens than cocks. In the area of highest population there were 43 pheasants per 100 acres, and in that of lowest density about 15 per 100 acres. Despite the apparent decrease in pheasant abundance as indicated by reports of previous years, hunting pressure during the season which had just ended was extremely heavy. Pre-season surveys would provide information for correcting such conditions.

CONCLUSIONS

Favorable aspects of the quadrat inventory method are: (1) a novice can obtain very accurate results if quadrats are properly selected; (2) the method permits state-wide inventories by field patrol officers while engaged in daily routine; (3) areas where upland game may not respond to management are indicated, permitting change in procedures or policies; (4) population trends and sex ratios are determined; (5) the method has proved to be conservative in evaluation, and management practices based on such conclusions are rarely detrimental to breeding stock.

Some weaknesses of the quadrat inventory are: (1) it involves much walking, hence takes time; (2) it is accurate only when sufficient samples are used (for the 2,700,000 habitat acres in the Willamette Valley, 150 quadrats are run periodically or one per 18,000 acres); (3) quadrats must first be established by a trained worker, since novices tend to select plots that produce the most game and thereby arrive at erroneous conclusions; and (4) when pheasant populations are in excess of one bird per acre, a correction factor must be applied. This is unimportant on most habitats since few carry so high a population.

SUMMARY

1. Methods to determine trends in pheasant populations have been sought to aid in improving game bird management in Oregon. The quadrat inventory proved practical, economical, and simple, and can be used by laymen as well as game managers.

2. Research on this method was begun by the Oregon Cooperative Wildlife Research Unit in 1937, after roadside counts and direct drives proved impractical because of the scarcity of roads and inadequate staffs. Careful analysis, after trial and error, has improved the plan which has been used in Oregon for several years

3. Traffic Station maps of the Oregon Highway Commission proved the most suitable base maps, and a field record book for entering details about each quadrat was necessary.

4. Experience indicates that a quadrat 1 mile long by ¼ mile wide, in average pheasant habitat, should be selected. The observer walks the perimeter of the quadrat and counts all birds within 100 feet on each side. Care must be taken to select the proper weather and time of day and to avoid periods when the birds may be inactive, such as the early morning, the hours be-

tween 11 a.m. and 2 p.m. on hot days, and the first wet and stormy days of autumn. The months of March and April and from August to December proved most successful in Oregon. Specific data are recorded by the field worker on cards. Total acreage then is determined by a formula: Perimeter in feet $\times 200 \div 43{,}560 =$ Acreage. Representative samples of habitat must be chosen to give a true picture of conditions.

5. Ten to 30 quadrats are censused in each geographical unit, and at least one for each 20,000 habitat acres; the maximum unit should not exceed 500,000 habitat acres.

6. An ideal testing-ground was found on the 394 acres of Protection Island, Washington, where a known population has been maintained since 1937.

7. Several Willamette Valley counties are seriously handicapped in managing pheasants because of the density of human population or of human interference, as shown by quadrat censuses in the autumn of 1939, 1940 and 1941. This method singled out the problem areas and served as a guide for improved game management.

8. Weaknesses of the method include the time involved to cover the quadrats and the necessity for enough samples to obtain accurate results; 150 quadrats are run periodically in the Willamette Valley.

LITERATURE CITED

SCOTT, T. G., and G. O. HENDRICKSON. 1942. Pheasant Management. Iowa Coop. Wildl. Research Unit, Quarterly Rept., July–Sept., 1942, p. 13.

BENNETT, L. J., and G. O. HENDRICKSON. 1938. Censusing the ringneck pheasant in Iowa. North Amer. Wildl. Conf. Trans., 3: 720–723.

HABITS, FOODS AND PARASITES OF THE BOBCAT IN MINNESOTA[1]

Clair T. Rollings

Division of Entomology and Economic Zoology, University of Minnesota, St. Paul, Minnesota

In Minnesota, little has been learned about the bobcat (*Lynx r. rufus*) because of its stealth, nocturnal habits, remote habitat, and relative scarcity. Woodsmen, farmers, and sportsmen acquainted with the animal disagree markedly concerning its habits and economic importance. Some farmers claim there is considerable predation on poultry and young livestock. Certain trappers and sportsmen strongly advocate a bounty, asserting that bobcats make serious inroads on game. Among these groups, there is every grade of opinion as to the seriousness of such predation.

---

[1] Paper No. 2195, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota.

This study was made in the Division of Entomology and Economic Zoology, University of Minnesota, under Gustav Swanson. Arnold B. Erickson assisted in editing the manuscript; Shaler E. Aldous, U. S. Fish and Wildlife Service, Jack Manweiler, U. S. Soil Conservation Service, both contributed specimens and notes; Carl Gilstad, trapper, assisted in the field.

There is practically no literature dealing with habits of the bobcat in Minnesota, and that from other areas is not entirely applicable to Minnesota conditions. Grinnell, Linsdale and Dixon (1937) say of the bobcat in California, "We believe the value of the bobcat in maintaining the proper regulatory check upon certain of the smaller mammals and birds is sufficient to justify the intentional preservation of it on uncultivated territory."

Inconsistencies in the bounty laws of various states for bobcats emphasize the uncertainty as to the economic status of the species. Such laws are continually being cancelled or added to the statutes. In Pennsylvania, where bobcat bounties have been paid for more than 100 years, there is now much agitation to remove the bounty and Gerstell (1937) says, "Because the bounty system has not only brought the bobcat under complete control, but even placed the species . . . on the verge of extinction, the payment of bounties for the killing of wildcats should be immediately discontinued and serious consideration should be given the thought of offering the species some form of protection."

Several excellent food studies have been made of the bobcat, but few workers have used field observations extensively. Hence, there often is question as to whether food items identified by laboratory analyses represented kill or carrion, and the seriousness of bobcat predation remained undecided.

The writer has combined field observations with laboratory analyses to determine the wisdom of bobcat control in Minnesota and to establish some facts concerning the life history and relationships of the species with game and domestic stock.

Scope and Procedure

Field data were accumulated over two full years, 1938–39. Most of the field observations were made between November and April when snow covered the ground and made tracking possible. Data and specimens were collected from north-central and northeastern Minnesota, Beltrami and Cook counties being studied most intensively. Notes on habits were taken in the field and specimens were collected for weights and measurements and for the study of food and parasites. Personal observations were supplemented by interviews with reliable woodsmen and trappers who also furnished many specimens.

Information on habits was gained chiefly by tracking immediately after fresh snowfalls. Tracking was difficult only after hard crusts had formed. Notes taken at the points of observation were supplemented by photographs of tracks, kills, habitat, and of bobcats themselves. Only a small part of the field data are from reports of trappers.

Viscera of preserved specimens were examined for foods and parasites in the University laboratories, and food items tabulated by frequency of occurrence and percentage of volume. Parasites were identified and placed in the University collection.

Classification and Description

Thirteen subspecies of bobcats have been described for North America, across the continent and from central Mexico to southern Canada. *Lynx rufus*

rufus ranges over almost the entire eastern half of the United States (Anthony, 1928), from North Dakota to Maine and Georgia. Recently its northern limit has been extended to include more of southern Canada.

The bobcat is closely related to the Canada lynx (*Lynx canadensis*); where the ranges of the two overlap they are often confused, but the following characteristics distinguish them. The bobcat's hind foot rarely exceeds 7 inches but that of the lynx averages 9 inches. Ear tufts rarely exceed 1 inch on the bobcat but are much longer on the lynx. The tail tip is black above and light below on the bobcat but solidly black on the lynx. Several indefinite black bars occur on the inner side of the bobcat foreleg (Pl. 4, A) which are not found on the lynx. The bobcat pelage is short, buffy, and much spotted with black, in contrast to the long and almost solidly gray pelage of the lynx. Mature specimens of the two species show that the bobcat is noticeably smaller, with much shorter hair, smaller feet, and less of a ruff on the chin. The lynx is seldom taken south of the Minnesota-Canada border and the bobcat extends only slightly north of that line.

Within the limits of normal variation, Minnesota bobcats agree with the type subspecies. They vary widely in pelage color from distinct buff with pronounced black spots and streaks in summer pelts to nearly solid gray in winter pelts. Apparently there is also a pelage change with age; larger (apparently older) individuals tend to lose many of the black spots and streaks which are quite consistent on smaller specimens.

The older, grayer specimens are commonly called "lynx cat" by trappers who maintain that the "lynx cat" is a distinct species with characteristics of both the bobcat and lynx. This name is so common that fur dealers quote separate prices for "lynx cat."

WEIGHTS AND MEASUREMENTS

Body measurements were taken of all unmutilated specimens (Table 1).

TABLE 1.—MEASUREMENTS OF MINNESOTA BOBCATS (IN INCHES).

	Body	*Tail*	*Right hindfoot*
Number measured	29	30	22
Maximum	40¼	6⅞	7⅝
Minimum	22½	4⅝	5⅛
Average	35½	5⅞	6⅜

Accurate measurements of many skulls were impossible because they had been crushed, but averages of 18 intact skulls are listed in Table 2. One unusual skull, with double incisors, was obtained.

TABLE 2.—AVERAGE SKULL MEASUREMENTS OF 18 MINNESOTA BOBCATS (IN MILLIMETERS).

Greatest length	118.8
Zygomatic breadth	82.8
Interorbital breadth	38.1
Length of nasals	32.1
Rostrum breadth	34.5
Palatal-frontal breadth	41.8
Basilar length of Hensel	100.5
Mastoid breadth	53.3
Greatest width between pterygoids	13.8

There is much discussion of the weight of bobcats. Trappers often report 40- to 50-pound specimens, but such appear to be over-estimates. Hamilton (1940) gave the average of 74 eastern bobcats as 15 pounds 4 ounces, the maximum being 36 pounds. Seton (1937) recorded a female bobcat from South Dakota (probably *Lynx r. rufus*) weighing 39¾ pounds

and Newsom (1930) a 35-pound specimen from Maine.

Twenty-seven bobcats were weighed during this study. The average of 4 unskinned specimens was 23 pounds 4 ounces, the lightest 10 pounds 2 ounces and the heaviest, 31 pounds 4 ounces. The average of 23 skinned carcasses was 17 pounds 15 ounces (lightest, 8 pounds 8 ounces; heaviest, 31 pounds 5 ounces). The difference in weight before and after skinning (when both weights were obtained) was 2 pounds 8 ounces. By adding this amount to the weights of skinned carcasses the average becomes 20 pounds 7 ounces (heaviest, 33 pounds 11 ounces; lightest, 11 pounds). The average corrected weight for all specimens was 20 pounds 14 ounces.

DISTRIBUTION

The bobcat apparently was not in northern Minnesota when the area was heavily wooded, but has shifted its range northward as the coniferous forests were removed by lumbering, fire, and farming. A large individual killed about 1910 by Frank Gibbs in Carlton County, was the first he knew of in that vicinity, and he believed it had come in from farther south after the forest had been cut. The northward shift evidently was not pronounced until after settlers moved into northern Minnesota and opened the forests still more. Surber (1932) says, "The range of the species covers the greater part of the state covered by deciduous forests . . . while its range extends north at least to southern St. Louis, and southwestern Lake Counties, . . . it is extremely rare if found at all in the heavy evergreen forest."

Apparently within the last 10 or 15 years the bobcat range has extended to include all of northern Minnesota and southern Ontario and Manitoba. Jim Hamilton, an old trapper on Lake Namakan along the Canadian border, claims there were no bobcats present 10 or 12 years ago but they now are numerous. On two extended field trips into that territory, the author found bobcat signs, identified several pelts, and determined that the species is now well established in extreme northeastern Minnesota. According to Joe Zerbach, an old and reliable trapper along the Gunflint Trail, the animal is a relatively new arrival there, but it is now well known by all local trappers and woodsmen living along that trail. On an automobile trip along the north shore of Lake Superior during June, 1940, the writer found that fur dealers had purchased pelts taken some 100 miles north of the Minnesota-Ontario border.

This evidence indicates a northward shift in range of 100 to 200 miles during the past 20 to 30 years, when man has altered the environment markedly.

POPULATION

By comparing field observations with known catches from several different areas it was estimated that the annual catch represents 10 to 25 per cent of the total bobcat population. This method was deemed sufficiently accurate to denote population trends which may give the information necessary for intelligent management. Manweiler (1939) reports an annual catch of 461 bobcats in Minnesota for the years 1930 to 1937, inclusive, indicating the average population as between 1,800 and 4,000 during that period. Avery (1916), reporting for the Minnesota State Game and Fish

Department, set the state population at 3,000.

There is considerable evidence to indicate that the population is unstable and passes through peaks followed by periods of decimation, due possibly to the fluctuation in the number of varying hare (*Lepus americanus*), the most important food source for the bobcat in this area. According to Robert Hunt, a fur dealer at Bemidji, Minnesota, there is a definite correlation between populations of varying hares and bobcats. He bought an average of 15 to 25 bobcat pelts annually in 1934 to 1936 when varying hares were abundant, but only 3 during 1938 and 1939 when hares were scarce. His report was substantiated by the opinions of trappers and other fur dealers throughout the area studied. The writer noted a scarcity of bobcats and varying hares during both 1938 and 1939, and all evidence confirmed the correlation between the two populations.

HABITAT

The preferred habitat of the bobcat in Minnesota now is second growth forest with much undercover, interspersed with numerous clearings and swamps. The species now is found in all forest types—hardwoods, conifers, and mixed. Both upland and lowland habitats are acceptable during the summer, but flooded or semi-flooded areas are avoided. In winter, heavily-forested coniferous swamps are preferred (Pl. 4, C).

Because the varying hare is an important food item in the bobcat's diet, its presence is an important factor in the selection of the latter's habitat. Protection from severe weather, availability of rest shelters, cover density, and freedom from disturbance also appear to be important.

Tracks indicated that bobcats spend much of the winter in the dense swamps of cedar (*Thuja occidentalis*) and spruce (*Picea mariana*) so common in northern Minnesota. There often were tracks at considerable distances from such swamps, but the animals usually returned to the lowlands after short trips into more open cover. During periods of food scarcity they are forced to hunt all types of cover, but when food is abundant they appear content to spend practically the entire winter in dense swamps.

Little information was gathered on summer habitat, because tracking then is impossible. Trapper reports and personal observations indicated, however, that the species is not confined to the swamps in that season. By April 17, 1939, the bobcats had vacated their favorite cedar swamp near Funkley, Minnesota, despite the presence of considerable snow and of varying hares. The accumulation of water from melting snows apparently forced the bobcats to seek higher ground. Further evidence of their dislike for water was gathered on a canoe trip along the Canadian border lakes during July, 1938. Tracks of a bobcat along a beach were followed for a half mile. Several times the animal had approached the lakeshore as if to examine something in the shallows but it never actually stepped into the water, and once detoured 100 feet up a small stream bank and crossed on a fallen log rather than wade the shallow water. A similar observation was made at the sandy beach of another lake on June 16, 1940.

Near Lake Namakan in June 1940, bobcats occupied a territory where

rocky cliffs were common. When available, this habitat seemingly is preferred in summer, for its inaccessible den sites and for the extra protection afforded the young. In general, a wider variety of cover was acceptable in summer than in winter.

TRACKS

Bobcat tracks are characteristically round and seldom show claw marks. The four toe pads leave small, rounded imprints, and the impression of the ball pad is of characteristic design. In muddy soil, hair impressions are left by the well-furred paws. In fresh snow, two inches or less in depth, the tracks (Pl. 5, A) are small and uniformly rounded, resembling those of the house cat but considerably larger. Trotting leisurely, a bobcat leaves evenly spaced tracks 10 to 13 inches apart, with one nearly behind another. Tracks irregularly spaced and less than 8 or 10 inches apart, indicate a walking gait or perhaps a "stalk." At full speed, the tracks are bunched and leaps of 7 or 8 feet are common. Brunner (1929) claims a running bobcat can leap 10 feet.

The individual tracks (not including the heel) are slightly longer than wide. Of the many measured, the smallest was $1\frac{1}{2}$ by $1\frac{1}{4}$ inches, the largest $2\frac{1}{4}$ by 2 inches, and the average 2 by $1\frac{3}{4}$ inches. Tracks with the entire length of foot recorded (heel to tip of toe) averaged $6\frac{1}{2}$ inches.

In deep, soft snow the bobcat leaves considerable "drag," and the resulting track resembles an irregular trough, punctured in the bottom with impressions of the feet and legs (Pl. 5, B). Sometimes it was difficult to distinguish a bobcat trail from that of a coyote in deep, soft snow. Both left considerable "drag," and individual foot impressions were much alike. The bobcat trail, however, was extremely crooked and meandered through dense cover, whereas that of the coyote was nearly straight and avoided the more difficult route.

The meandering habit often led a bobcat to cross its own trail, and at times even to backtrack or retrace its own footsteps for a short distance. A bobcat is adept at stepping in its own tracks or those of another bobcat, which sometimes made tracking difficult. After puzzling out the seemingly aimless wanderings of a bobcat for an entire day, the tracker often found himself less than a mile from his starting point.

RANGE

Seton (1937), basing his opinion upon probability, estimated the home range of a bobcat as no more than 1,000 acres in a region where food is plentiful, but larger in a starved land. According to Sumner (1931) the home range is at least five square miles. The bobcat travels in circles of 4 or 5 miles per night (Grinnell *et al.*, 1937).

Observations on the cruising radius of Minnesota bobcats generally agree with the preceding statements, but there was considerable variation, apparently influenced by food availability, in the distance traveled by an individual during a single night of hunting. To determine this distance it was necessary to establish definite starting and stopping points and to be certain that the distance measured had been traveled in 24 hours. When snow conditions were right, it was possible to get this information with accuracy, using a pedometer.

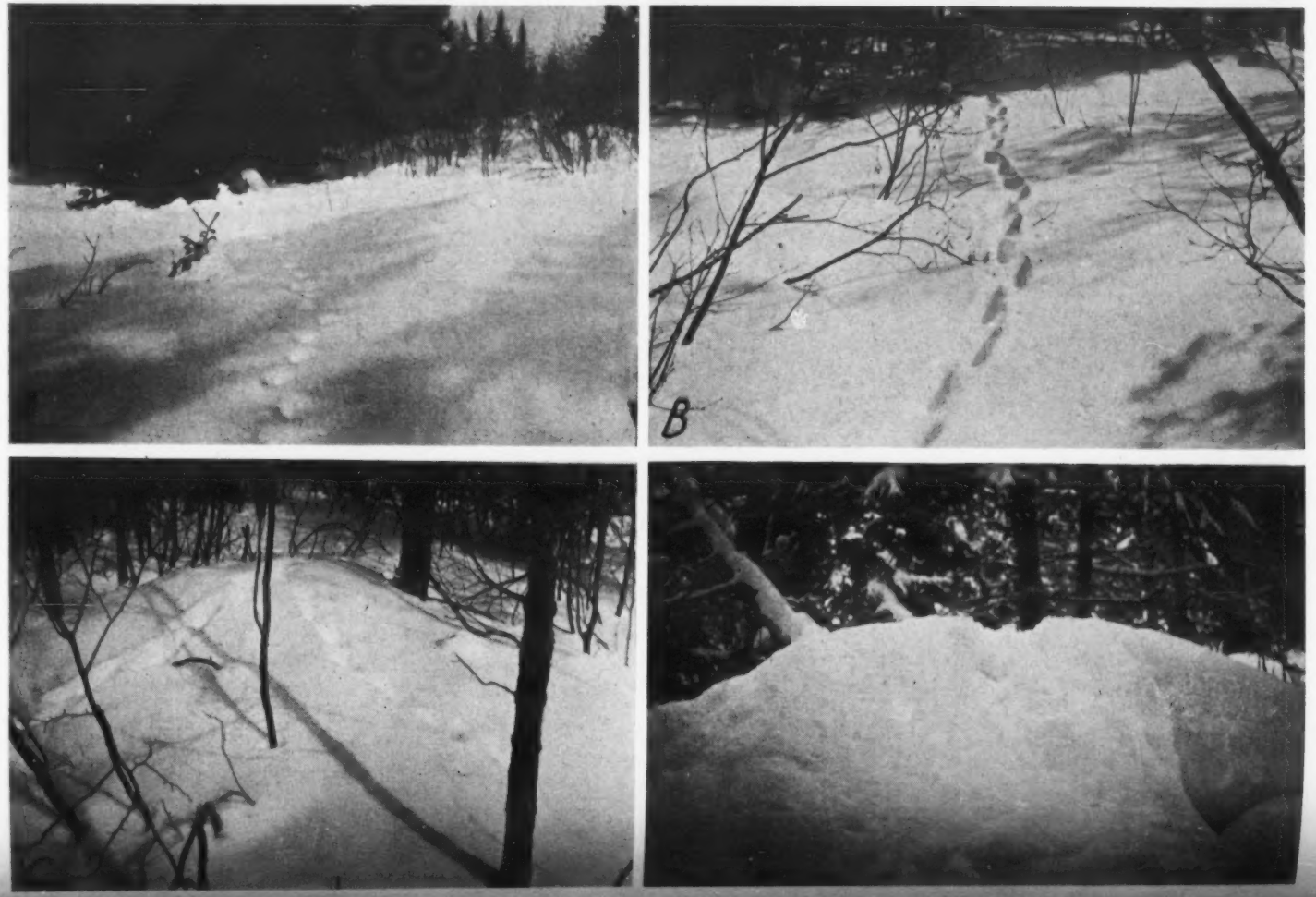
oot im-
bobcat
crooked
e cover,
s nearly
difficult

n led a
and at
trace its
listance.
its own
bobcat,
ng diffi-
emingly
t for an
nd him-
starting

on upon
ne range
000 acres
iful, but
rding to
ge is at
bobcat
niles per

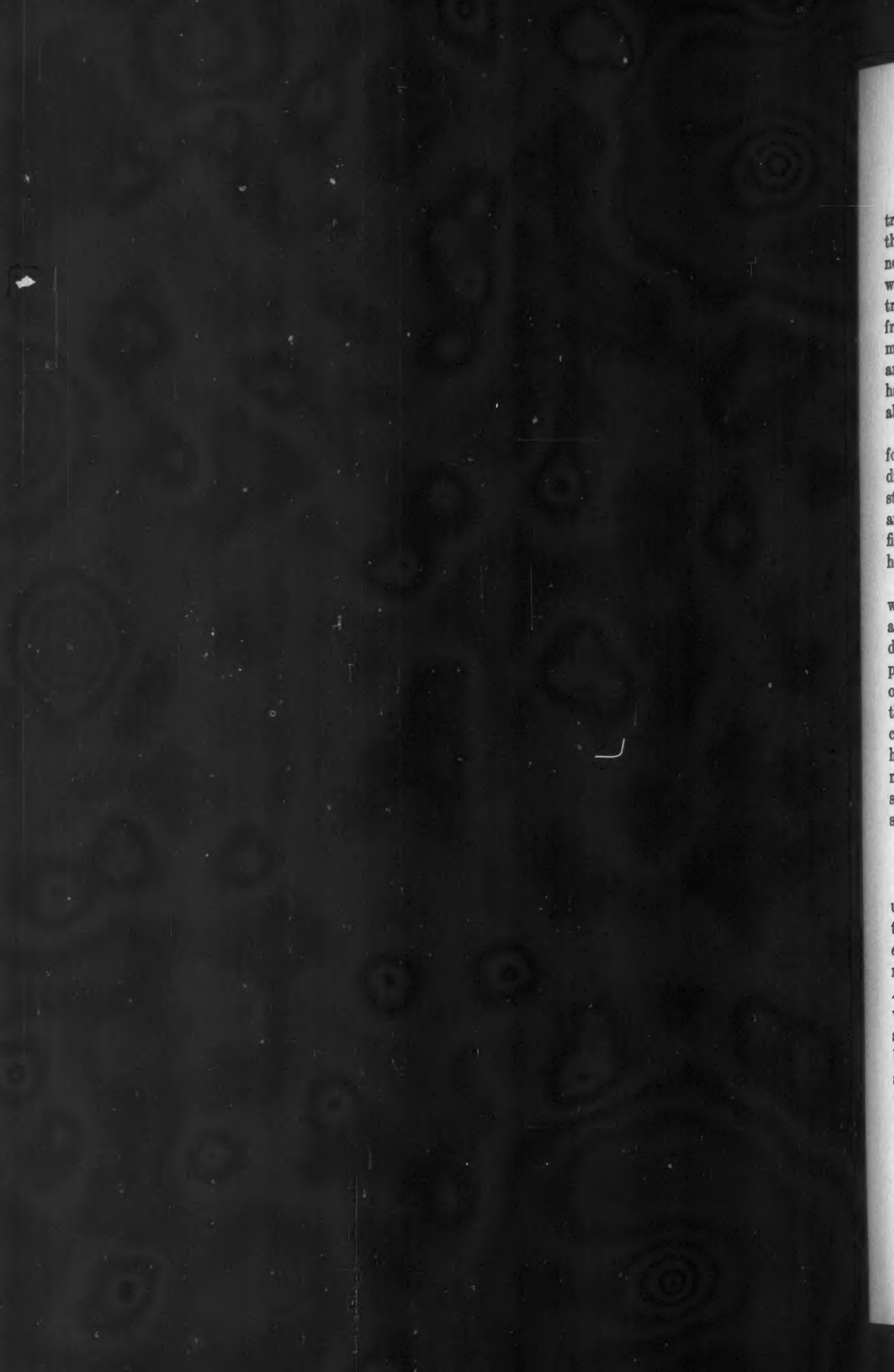
g radius
ly agree
nts, but
ion, ap-
availa-
d by an
night of
stance it
definite
nd to be
ured had
en snow
ssible to
ccuracy,

The bobcat in Minnesota. *A*. Trapped individual, showing the black bars on inner side of foreleg. *B*. Bobcat caught in snare; chewed twigs and other debris on snow about the animal. *C*. Spruce-cedar swamp, a preferred winter habitat of the bobcat in Minnesota.



The bobcat in Minnesota. *A*. Tracks in shallow snow. *B*. Tracks in deep snow. *C, D*. Favored "lookouts" from which bobcats often watched for approaching prey.

The bobcat in Minnesota. *A*. Tracks in shallow snow. *B*. Tracks in deep snow. *C, D*. Favored "lookouts" from which bobcats often watched for approaching prey.



On five occasions bobcats were tracked from rest shelters left during the evening to those entered early the next morning. The distance between was considered the hunting range traveled during the night; it varied from 3 to 7 miles and averaged 5½ miles. Varying hares then were scarce, and the hunting range possibly would have been less if food had been more abundant.

Due to the extremely tortuous course followed, the cruising radius (greatest distance in a straight line from the starting point) was as little as ¾ mile and the longest only 3¾ miles. These figures emphasize the bobcat's habit of hunting intensively within a small area.

The cruising radius for longer periods would be greater because the bobcat is an aimless hunter and often uses a different rest shelter each day. The population density of prey and the area of winter habitat apparently influence the seasonal cruising radius. The bobcat was found not to be a nomadic hunter; apparently each individual remains within an area 10 to 15 miles square even when under a severe food shortage.

HUNTING HABITS

The bobcat has exceptional eyesight, upon which it largely depends in obtaining food (Gr. *lynx*, to see). Grinnell *et al.* (1907) state that trappers, recognizing this, often use moving baits. Arthur (1931) credits the bobcat with very keen eyesight and much ability in stalking. Various observers report that bobcats stalk their prey by creeping stealthily behind every bit of cover and watching the victims intently until able to overtake them by a few powerful leaps. These traits rather than sustained speed in pursuit are used to obtain food.

No kills were witnessed by the writer but much information was obtained on hunting methods and food habits by extensive tracking. Trail sign indicated that a bobcat obtained prey either by creeping behind cover, or by patient waiting, crouched atop a log, stump, or other vantage point, until the prey chanced to pass on a nearby trail that could be reached by a few short leaps. The bobcat constantly haunted trails of the varying hare, and searched carefully through thickets, under windfalls, and about upturned roots. On the trail it usually advances by a steady trot, but stops often as if to survey the trail ahead or to watch some movement. It then may continue if nothing special has been seen; or it may crouch and slink forward (indicated by irregular tracks and deep snow drag); or it may suddenly leap in pursuit of observed prey. If the victim is not captured after a short burst of speed, the chase usually is abandoned. Apparently a bobcat does not follow individual tracks with the intent of catching a particular individual, but is an aimless hunter, abandoning one trail after another, depending upon its eyes to "mark down" any moving object within its field of vision.

Bobcats had favorite "lookouts" near well worn game trails (Pl. 5, C, D) from which they could watch the movement of game. Apparently they spent much time on these snow-covered perches in wait for passing prey, as evidenced by hairs frozen into the packed snow. Sign indicated that a bobcat would flatten itself at the approach of a hare and then spring suddenly from the "lookout."

The location of deer carcasses and other carrion is apparently well known to the bobcat, and such are seldom

passed without investigation. If hungry, the bobcat will not hesitate to gorge itself on carrion.

Trappers state that the bobcat will kill and eat the porcupine (*Erethizon dorsatum*) when the varying hare is scarce. No positive evidence of porcupine kills was found, but food analyses showed porcupine flesh as the third most frequent food item in 50 bobcat stomachs. The bobcat reportedly deftly flips a porcupine onto its back and attacks the belly which is relatively free from quills; such attacks probably are attempted only when the porcupine is on the ground. On one occasion tracks indicated that a bobcat failed to attack a porcupine which it evidently saw feeding in a tamarack tree about 15 feet above the snow. The absence of porcupine tracks and the isolated location of the tree (the porcupine was still feeding when seen by the observer) proved that it had remained in the tree since the last snowfall and was there when the bobcat came to investigate. The latter circled the tree several times but departed without approaching closer than 4½ feet.

The bobcat is often accused of climbing trees to kill roosting birds, but all trail observations but one tended to disprove this accusation. Tracks showed that a bobcat had climbed one spruce and crossed on intertwining branches to come down a neighboring tree. No feathers or other evidence of a kill were noted. The amount of hunting by bobcats in trees evidently is negligible.

Hamilton (1939) and Seton (1937) record instances of bobcats catching and killing housecats. Near Akeley, Minnesota, one entered a barn and killed a housecat; the bobcat was shot by the farmer and found to be emaciated, apparently from starvation.

The bobcat hunts small animals almost entirely. Rarely it may attack deer, but Dearborn (1932) believes it will not disturb deer when varying hares are plentiful. Hamilton (1939) believes that a very large bobcat (30 to 36 pounds) is capable of pulling down a deer in deep snow, but that much of the deer flesh found in the bobcat stomachs he examined from Vermont was carrion. The California bobcat may on occasion attack deer, but such predation is not common (Grinnell *et al.*, 1937). In Maine Newsom (1930) recorded two deer killed by a large bobcat, and thinks attacks on deer are quite common. Marston (1942) reports that bobcats in Maine during 1939–40 killed 18 deer and in 1940–41 killed 37. His findings are unusual as compared with those from other areas.

The only authentic observation of an attack on deer in Minnesota was made by Jack Manweiler of Baudette on January 10, 1941. Tracks indicated that the bobcat had attacked the deer in its bed about mid-forenoon. When first seen, at 11:00 a.m., the bobcat was clinging to the rear quarters of the deer and a lively struggle was in progress but the animal was frightened away. The bobcat was seen by Mr. Manweiler again at 2:00 p.m.; it was struggling with the deer, and fastened to the deer's lower jaw. As a result of the long struggle of 3 to 5 hours, the deer was nearing exhaustion and would have succumbed had there been no interference. Later the deer was shot for examination; it was a 2½ year buck weighing 165 pounds. An old gunshot wound had stiffened its left rear leg, an undoubted handicap, but otherwise the animal was in good physical condition.

The attacking bobcat (evidently the same as indicated by track comparisons) was trapped at the carcass the following night. It weighed 10 pounds after being skinned, or 12 to 14 pounds alive. Although not noticeably emaciated, it appeared to have been without food for several days and probably was ravenous.

During extensive tracking through more than two years, the writer regularly visited many deer yards but saw no positive evidence that the bobcat attacks or kills deer, even under conditions which would have made the task relatively easy. In northern Minnesota during the last week in March and first week in April, 1939, the snow was still 16 to 18 inches deep and heavily crusted. Deer, weakened by a long winter in the yards, were dispersing in search of food. The crusted snow hindered their progress so that they could be overtaken by a man on snowshoes and certainly would be at the mercy of large predators. Three days spent in searching for evidence of bobcat predation on deer revealed none.

On June 15 to 17, 1940, the writer was at Junction Bay on Namakin Lake to gather data on fawn predation and bobcat dens (both deer and bobcats were numerous and bobcat predation reported heavy). Local trappers were interviewed, and deer trails were followed for evidence of predation. A few trappers believed that bobcats killed some fawns, but could recall no specific instances observed during that season. Many does with fawns were seen but no signs of predation.

All available data indicate that the bobcat in Minnesota rarely attacks deer. Wounded, weakened, or exhausted deer may be attacked occasionally. The most aggressive bobcats may attempt to take deer in good physical condition but in the aggregate such predation is of minor importance in Minnesota.

OTHER HABITS

The bobcat is so shy and retiring as to be seen by few persons in its native haunts. Many settlers in Minnesota were positive that there were no bobcats in their neighborhoods although tracks often indicated that the animals were quite common. Hunting by night and retiring to secret hiding places by day, bobcats are seldom seen, even if tracked to their hideouts.

The author tracked several individuals to their hiding places only to find that they had quietly departed shortly before the rest-shelter was discovered. Only one bobcat was observed leaving its daytime hideout; it jumped some 10 feet to the snow from a dry hollow pine and made straight for the nearest cover with long, easy, and graceful leaps. It was within 100 feet when first observed, but made no audible sound.

The bobcat has a highly developed sense of curiosity. Bits of paper, cloth, orange peels and cigarette packages thrown to the side of a snowshoe trail were almost invariably investigated by passing bobcats. Such trails often were followed by the cats for considerable distances, although they led out of the usual hunting territory.

Instances of woodsmen being terrified by screams of wildcats are often mentioned in popular fiction. The bobcat, however, is inclined to be silent and seldom uses its vocal powers. At no time during the course of this study was the voice of non-captive bobcats heard. Grinnell *et al.* (1937) state that the cry of one bobcat was a series of noises be-

tween a bark and a yowl, resembling that of the domestic cat, but not so prolonged. Stone and Cram (1905) say the bobcat utters wild screams from time to time when hunting, and low growls followed by sudden, rapidly repeated caterwauls. Both untamed, captive bobcats and specimens caught in snares were observed by the writer. They uttered deep growls when approached, and kept unblinking eyes fixed upon the observer. Further advance or quick movement caused them to bare their teeth, open their mouths (Pl. 4, A, B), and emit muffled hisses often followed by spitting noises.

Bobcats occasionally use "stretching trees." Dry, hardened snags without bark usually were selected for the purpose of stretching, sharpening the fore claws, or for some other unknown reason. Small claw marks on the trunks and tracks in the snow indicated that the bobcats had stood erect on their hind feet to stretch up with the fore claws and dig into the wood. On one occasion tracks indicated two bobcats had used the same tree. Such trees are apparently used frequently.

Relatively few droppings were observed because bobcats usually defecate off a beaten game trail and cover their droppings; also the warm seats settle into soft snow. It appeared that a bobcat deliberately went a few feet from the main trail to deposit its feces, usually on a hummock of snow at the base of a stump or atop a snow-covered log. There was a definite tendency to seek a slightly elevated spot. On two occasions droppings had been covered with snow, but usually only feeble attempts were made to do so, and one scat, only 2½ feet off a main trail was uncovered. No droppings were found in the well worn game trails commonly followed by bobcats.

The bobcat has fur shorter than that of the Canada lynx, yet the animal can withstand severe winter weather. Trail sign indicated on many occasions that bobcats had been active at temperatures well below 0°F. One had been hunting near Lake Namakin during the night of December 31, 1939, when the temperature was −30°F. There was some indication that bobcats remained in shelters during severe blizzards, but on clear cold nights hunting continued as usual.

SHELTERS AND DENS

The term "rest-shelter" is used to designate the temporary hiding place occupied during the day. Rest-shelters were found under windfalls, in standing hollow snags, and in hollow logs on the ground. One bobcat had used the overhanging roots of an upturned tree. These hiding places usually were occupied only one day at a time, or at most for a few days in succession. The aimless hunting habit and relatively short cruising radius of the bobcat apparently necessitates the use of different rest-shelters almost every successive day. Evidently the locations of all acceptable rest-shelters in the rather limited winter hunting range were well known, and the most convenient one was selected at the end of each night of hunting.

The term "den" is used to designate any shelter occupied by bobcats during the spring and summer when the young are born and reared. The bobcat will accept a wide variety of dens providing they are dry, well hidden, and inaccessible. Hollow trees and rocky cliffs are mentioned most frequently in the

literature, although there are records of dens in windfalls and fallen logs.

Ole Hildeblad, a trapper at Saum, Minnesota, found four young bobcats in a standing, hollow white pine, with an opening about five feet above the ground. Returning the next day to capture the young, he found them gone, evidently moved to a new location by the mother.

Along the sandy beach of Net Lake in June 1940, the author found many bobcat tracks that led toward and away from the boulder-strewn talus of a rock cliff bordering the lake on the south; the bobcats probably were using rock crevices for dens, but the latter could not be examined.

FOOD HABITS

In Michigan, Dearborn (1932) analyzed over 300 bobcat feces and found the varying hare to comprise 89.6 per cent of the foods identified. He commented, "The bobcat will not disturb deer when varying hare are plentiful—no grouse remains in over 300 faeces although grouse were plentiful."

Hamilton and Hunter (1939) found deer, mice, hares, and rabbits the most important foods in 140 bobcat stomachs from Vermont, but were of the opinion that much of the deer was carrion.

In California, Dixon (1925) analyzed the contents of 186 bobcat stomachs and stated, "I find that in California certain so-called predatory mammals such as the wildcat and skunk are, in the aggregate, beneficial and not harmful to human welfare."

McLean (1934) examined 156 bobcat stomachs from California and found the woodrat to be the chief food. Valley quail were plentiful in the region where the specimens were collected but only five stomachs contained remains of these birds.

The following discussion of the food habits of the bobcat in Minnesota is based on the author's field observations and analyses of 50 stomachs collected between November 1936 and January 1941. More than 75 per cent were taken during 1938 and 1939, the majority in January to March. The earliest fall collection was on October 14, and latest spring collection on April 15 (Table 3).

TABLE 3.—FOOD IN 50 MINNESOTA BOBCAT STOMACHS, COLLECTED NOVEMBER 1936 TO JANUARY 1941.[a]

Item	*Frequency of occurrence*	*Percentage by volume*
Varying hare	26	*44.1*
White-tailed deer	22	*35.0*
Porcupine	10	*12.3*
Shrew	5	*2.5*
Mice	1	*1.8*
Woodchuck	1	*1.8*
Ruffed grouse	1	*1.4*
Canada lynx	1	*1.0*
Squirrel	2	*0.9*
Skunk	1	*0.3*
Blue jay	1	*0.2*

[a] Including 9 collected and analyzed by Shaler E. Aldous, U.S. Fish and Wildlife Service.

Varying hare. The population of varying hares (*Lepus americanus*) was low throughout the 4 years, especially in 1938 and 1939. Field studies indicated that bobcats spent much of their time in pursuit of hares, and these observations were substantiated by the stomach analyses. Hares, despite their scarcity, were the most important source of food. Had the hare population been high, an even greater proportion probably would have been taken.

White-tailed deer. Most of the deer (*Odocoileus virginianus*) recovered probably was carrion. Bobcat tracks and evidence of feeding about several reported "kills" were taken to mean (by

other persons) that bobcats were responsible when in reality they acted only as scavengers. Two carcasses had gunshot wounds and starvation or injury were believed to have been the cause of death in other deer. The writer often tracked bobcats to old deer carcasses and noted that they had eaten heartily. This scavenging habit is so well known among trappers that snares and traps were usually placed near such carrion. Two deer carcasses in a spruce-cedar swamp near Funkley, Minnesota, during the winter of 1939 were visited regularly by a pair of bobcats. Apparently they had little else to feed on, due to the scarcity of varying hares. By late March the carcasses were picked clean; the bobcats must have been greatly in need of food. Even under these conditions there was no indication of attack on the live deer yarding in the same swamp.

Porcupine. The bobcat apparently can kill and eat a porcupine (*Erethizon dorsatum*) without serious results. One of every five stomachs examined contained porcupine, which was third on the list of bobcat winter foods. One bobcat had eaten 150 cc. of porcupine flesh. Nine quills were found in its stomach, three of which had penetrated the stomach wall. There were several others in the fat surrounding the intestines and others had penetrated both the body wall and outer skin. All of the quills were somewhat softened. A portion of a porcupine's foot with 3 complete claws attached was recovered from the same specimen. This bobcat was in good physical condition and had apparently suffered no serious effects. Because the porcupine remains active throughout the winter, it can be regarded as an important bobcat winter food.

Shrew. Remains of shrews (*Blarina brevicauda* and *Sorex cinereus*) were found in five stomachs or 10 per cent of all examined. Field observation indicated considerable effort was expended in search of small mammals. Bobcats often followed shrew or mouse tracks in the snow and one bobcat attempted to scratch its way into a well rotted pine snag, apparently in search of shrews or mice. The shrew must be considered of some importance as winter food although the volume is small.

Mice. Only one meadow mouse (*Microtus pennsylvanicus*) was recovered, from a stomach taken November 28, 1938. Because collections were made largely during January, February, and March when heavy snows covered the ground, it is probable that few mice were available because of their activity beneath the snow. In Vermont, according to Hamilton and Hunter (1939), mice are taken more frequently than any other food during autumn and winter, but the majority of their collections were made during October to December, possibly before deep snows.

Woodchuck. One bobcat taken December 18, 1937, contained woodchuck (*Marmota monax*). This animal is seldom or never active in northern Minnesota at this date and the meal probably was carrion.

Ruffed Grouse. One bobcat, taken March 7, 1937, had eaten ruffed grouse (*Bonasa umbellus*). On the basis of bulk percentage this meal represented 1.4 per cent of all foods taken by 50 specimens. Ruffed grouse were scarce in 1937 and 1938, but sufficiently abundant in 1939 and 1940 to warrant open hunting seasons. No bobcats taken in 1939–40 contained ruffed grouse. Two apparent attempts to stalk ruffed

grouse hidden in the snow were observed, but both failed. Investigators in Michigan, Vermont, and California have found ruffed grouse to form a very small portion of bobcat food even when the grouse are abundant. Both field sign and stomach analysis have shown few grouse captured by bobcats in Minnesota, and the latter can have little effect on the grouse population.

Miscellaneous. Meals of squirrel, skunk, blue jay, and Canada lynx were taken infrequently and in insignificant amounts, representing rare catches or meals of carrion. Many stomachs contained much debris—twigs, bark, or soil—within reach of trapped individuals (Pl. 4, B). Some surprisingly large sticks were chewed and swallowed, one stomach containing a Y-shaped piece of alder 1⅝ by 1⅛ inches. Another bobcat evidently had chewed off and swallowed two of its own claws. Grass and white cedar leaves were present in a high percentage of stomachs. In specimens shot or choked quickly by snares it was obvious that the grass and leaves were not trap debris; they were taken intentionally or were ingested with deer offal frequently encountered in the woods.

Many stomachs contained only one food item, and only a limited variety of foods was recovered from all specimens. In general the foods were poorly masticated. One piece of deer flesh measuring 3½ by 2 inches and weighing 22 grams had been bolted without chewing. Shrews and mice were recovered almost entire. The largest meal recorded weighed 580 grams (moist) and consisted of varying hare and deer flesh.

WORM PARASITES

The gastro-intestinal tracts of the 50 bobcats also were examined for helminth parasites (Table 4) and 13 examinations were made by Dr. O. W. Olsen and Dr. A. B. Erickson, University of Minnesota.

TABLE 4.—HELMINTH PARASITES FROM GASTRO-INTESTINAL TRACTS OF 50 MINNESOTA BOBCATS.

Parasite and location in organs	*Bobcats parasitized*
Toxocara cati,[a] intestine	21
Toxascaris leonina, intestine	2
Physaloptera praeputialis, stomach	1
Physaloptera sp., stomach	2
Ascarinae, intestine	2
Spirocerca sanguinolenta?,[a] stomach	1
Toxocara sp., intestine	1
Taenia taeniaeformis, intestine	7
Taenia pisiformis,[a] intestine	5
Taenia hydatigena, intestine	3
Taenia rileyi,[a] intestine	2
Taenia monostephanos?,[a] small intestine	1
Taenia krabbei, small inestine	1
Unidentified, small intestine	1

[a] Apparently not previously reported for the bobcat in literature but listed in monthly parasitology reports, Division of Entomology and Economic Zoology, University of Minnesota.

In 36 bobcats (72%) there were one or more of 13 different helminth parasites The nematode *Toxocara cati* was recovered most frequently (18, or 36%), and in greatest individual infestation, 44 worms from one host. Six other nematodes were recovered.

Of cestodes, *Taenia taeniaeformis* was most frequent, in 7 (14%) and 18 of these worms were taken from one host. *Taenia pisiformis* was recovered from 5 bobcats.

The bobcat is the definitive host for the parasites reported in this paper. Alternate hosts are known to be deer for *Taenia krabbei* and *Taenia hydatigena*, mice for *Taenia taeniaeformis*, and hares and rabbits for *Taenia pisiformis*. The alternate hosts for *Taenia monostephenos* and *Taenia rileyi* are unknown. It is significant that animals known to be alternate hosts for the

cestodes reported were represented in the food analyses above.

All infestations were relatively light, and it is doubtful that even the heaviest had any serious effect on the host.

SUMMARY

1. Field data on bobcats were gathered in northern Minnesota during 1938 and 1939, mainly in winter, and 50 were collected for studies on food and parasites. Trail notes were used extensively to interpret food habits indicated by stomach analyses.

2. Minnesota bobcats show considerable pelage change with season and age. Large specimens often are called "lynx cats" and are confused with Canada lynx.

3. In recent years, the northern limit of range for the bobcat has extended 100 to 200 miles to include southern Ontario.

4. Spruce-cedar swamps are preferred winter habitat. Winter range is no more than 10 to 15 miles square, often less.

5. An average of 5½ miles was traveled in a night's hunting. Food is obtained largely by scavenging and by hunting small mammals. Birds are seldom sought. Stalking is a favorite method and elevated "lookouts" along game trails often are used. Deer are seldom attacked.

6. Bobcats are stealthy and shy but curious, and often will follow human trails to investigate every bit of scrap thrown aside. Droppings usually are deposited off the trail, preferably on an elevated spot, and sometimes are covered. Bobcats spend the daylight hours mainly in temporary "rest-shelters."

7. Varying hare, deer, and porcupine comprised over 90 per cent of the foods recovered from 50 specimens. The deer material was largely or all of carrion. Although scarce at the time of this study, the varying hare ranked first among the foods. No evidence of poultry or domestic stock was found in stomach contents.

8. The damage to Minnesota populations of deer and ruffed grouse attributed to bobcat predation is negligible.

9. Thirteen different helminth parasites were recovered from the gastro-intestinal tracts of 50 bobcats, 5 apparently not previously reported from this host.

10. Because the bobcat assists in the control of the varying hare, porcupine, and certain small mammals, it must be considered beneficial. A state bobcat bounty appears unnecessary and unwise. Its effect would ultimately be harmful to the interests of farmers, sportsmen and others interested in wildlife conservation.

LITERATURE CITED

ANTHONY, H. E. 1928. Field book of North American mammals. New York, G. P. Putnam's Sons, pp. 166–167.

ARTHUR, S. C. 1931. The fur animals of Louisiana. Louisiana Dept. of Conservation Bul., **18**, pp. 139–144.

AVERY, CARLOS. 1916. Minnesota State Game and Fish Commission, Bien. Rept.

BRUNNER, JOSEF. 1929. Tracks and tracking. New York, Macmillan Co., pp. 101–106.

DEARBORN, NED. 1932. Foods of some predatory furbearing animals in Michigan. Univ. of Michigan, School of Forestry and Conservation, Bul. 1, pp. 28–30.

DIXON, JOSEPH. 1925. Food predilections of predatory and furbearing mammals. Journ. Mammalogy, **6**: 34–36.

GERSTELL, RICHARD. 1937. The Pennsylvania system. Pennsylvania Game News, **7**: 8–10, 15, 24.

GRINNELL, JOSEPH, JOSEPH S. DIXON, and JEAN M. LINSDALE. 1937. Fur-bearing mammals of California. Berkeley, Univ. Calif. Press, **2**: 590–625.

HAMILTON, W. J., JR. 1939. American mammals. New York, McGraw-Hill Book Co.

1940. Weights of eastern bobcats. Journ. Mammalogy, **21**: 218.

HAMILTON, W. J., JR., and R. P. HUNTER. 1939. Fall and winter food habits of Vermont bobcats. Journ. Wildl. Mgt., **3**: 99–103.

MANWEILER, J. 1939. Minnesota fur bearers and problems of using them properly. Univ. of Minnesota, Wildlife Conservation Short Course, Abstract of papers, pp. 49–54.

MCLEAN, D. D. 1934. Predatory animal studies. Calif. Fish and Game, **20**: 30–36.

MARSTON, M. A. 1942. Winter relations of bobcats to white-tailed deer in Maine. Journ. Wildl. Mgt., **6**: 328–337.

NEWSON, W. M. 1930. The common bobcat a deer killer. American Game, **19**: 43–50.

SETON, E. T. 1937. Lives of game animals. New York, Doubleday Doran. **1**: 212–247.

STONE, WITMER, and W. E. CRAM. 1905. American animals. New York, Doubleday, Page & Co. pp. 284–286.

SUMNER, E. L., JR. 1931. An outline of the habits of the bobcat with some directions for trapping. Calif. Fish and Game, **17**: 251–254.

SURBER, THADDEUS. 1932. The mammals of Minnesota. Minnesota Division of Game and Fish, St. Paul.

A WINTER STUDY OF MULE DEER IN NEVADA

C. M. Aldous

U. S. Fish and Wildlife Service, Ogden, Utah

Prior to about 1925, mule deer (*Odocoileus hemionus*) were not noticeably abundant anywhere in the intermountain states and no deer problem areas were apparent on the range. Certain factors were at work, however, and collectively have affected both the future of the deer and their environment. Many refuges had been established and "buck laws" were in operation in most places. Also there had been much predatory animal control, on both the high mountains and plains. The U. S. Forest Service has regulated the grazing of domestic livestock on the national forests, which tended to reduce the number of cattle and sheep on much of the deer range.

The cumulative effect of all these regulatory procedures on the deer was extensive. Deer populations mushroomed to extremely high levels in favorable localities, and these sporadic build-ups occurred so rapidly that few people realized their extent or their ultimate effect on the deer and deer ranges.

The mule deer of the Intermountain region spend the summer in the high cool mountains. With the cold winds and heavy snows of winter they are forced to the lower foothill slopes and onto the flats, where there is less snow to impede their movements and food is more accessible. On the summer ranges, the deer feed over wide expanses, but in winter they are restricted to smaller areas. In consequence, the available winter food is used more quickly and completely than that on the summer range. The winter ranges therefore are first to show evidence of overuse and to become problem areas. The

first instance was the well known Kaibab herd of northern Arizona. This was soon followed by the Beaver Mountain herd on the Fishlake National Forest in Utah, and that on the Middle Fork area of Salmon River in Idaho. Since then such "hot spots" have become numerous in many western forested areas. When such a population gets out of hand, two major catastrophes are certain. The winter range becomes so badly overused that many years of careful management are required to restore it to full usefulness, and the deer herds are decimated and wasted through starvation. There is a loss of much good meat and of recreation for the sportsman.

Game managers and investigators agree that such useless and avoidable disasters can and should be largely averted in the future. Certainly it is more desirable to prevent these disastrous build-ups than to attempt restoration of an impoverished range and a decimated herd.

Recognizing the need for intensive study of overbrowsed winter areas and of areas approaching this stage of overutilization, the U. S. Forest Service enlisted the help of the U. S. Fish and Wildlife Service to conduct such work. The present study began in the autumn of 1941 and was confined to the Schell Creek Division (27,520 acres) of the Nevada National Forest in east central Nevada. The six main objectives were to learn:

1. A simplified and relatively accurate method for winter census of deer.
2. A practical and reliable means to determine the annual percentage utilization of each browse species on winter deer range.
3. A similar means to determine the optimum degree of utilization for important winter browse species.
4. The sex ratio removals necessary to keep a deer population at the proper carrying capacity of its winter range.
5. The nutritive values in various parts of twigs of the current year's growth.
6. The rate of browse recovery under varying degrees of exclosure protection.

METHODS

Work of the first year was largely exploratory, but gave valuable information and suggestions for the future. During the first two years, winter censuses were most satisfactory when delayed until the first green vegetation had appeared; the deer then tended to concentrate in large groups on such forage in the foothills and valley fringes. The most accurate counts were made as the deer were trailed in long columns toward dense cover at higher elevations.

The census period should be short, on a systematic plan, and unit counting areas should not be larger than three or four men can cover properly on horseback in one day. To eliminate duplications, deer should not be driven to areas to be censused later. Taking advantage of the terrain and working in clear weather helps toward an accurate count. Data on sex and age classes are best taken late in the autumn before bucks have shed their antlers and while there is still marked difference between the fawns and mature deer; if possible at least 500 animals should be examined.

CENSUS AND SEX RATIO

On the range under investigation,

1,230 deer were counted during the spring of 1942 and 2,009 in the spring of 1943. The increased number resulted from a better counting method during the second year and also from a substantial increase in the herd.

A sex ratio count late in the autumn of 1942 showed 24.0 per cent bucks, 37.5 per cent does, and 38.5 per cent fawns; the buck-doe ratio was 1:1.5. A larger buck removal could be made and still ensure a satisfactory breeding potential; probably one buck to four does is ample. For the 1943 hunting season there would have been (according to previous studies) 869 bucks and 1,140 does besides the animals less than one year old.

UTILIZATION OF BROWSE

To determine available utilization percentages, measurement plots were established for each important native browse species on representative sites over the study unit. Studies were conducted on curlleaf mahogany (*Cercocarpus ledifolius*), bitterbrush (*Purshia tridentata*), and cliffrose (*Cowania stansburiana*). Each of 8 or 9 bushes on a plot was marked with a numbered aluminum tag. Two lateral branches also were tagged and the current growth on each, between the tag and end of the limb, was measured in early November before the deer came to the winter range. The same limbs were remeasured late in May, immediately after the deer departed for the summer range. The difference between the combined total lengths before and after browsing represented the linear amount consumed. No livestock used the range in the interval between the two measurements and any use shown was that by deer. Sample results of the utilization of *Purshia tridentata*, in 1942–43, were as follows:

Plot No.	*Total removed (inches)*	*Percentage use*	*Average current growth (inches)*
1	134	*42*	1.45
5	396	*60*	2.13
6	475	*78*	1.60
8	177	*16*	1.90
12	1,368	*51*	2.60

Such plots were established for mountain mahogany, bitterbrush, and cliffrose. Calculations after measurements made in the spring of 1943 showed that bitterbrush was utilized 51 per cent, cliffrose 38 per cent, and mahogany 100 per cent; no measurments were made on juniper. Aside from the curlleaf mahogany, the use of cliffrose and bitterbrush as a whole probably was not excessive, but two bitterbrush plots showed usage of more than 70 per cent, which is believed to be excessive and not conducive to continued vigor.

A series of controlled plots has been established where clipping can be done to simulate browsing conditions closely; these will show the degree of utilization that each important browse species can endure, yet make satisfactory growth and retain full vigor. The current growth will be clipped 25, 50, 75, and 100 per cent, respectively, on different plants, for a period of five or more years; this will be done between November and April, the period after current growth has ceased and before new growth has commenced. Twig lengths and weights will be recorded for comparison with succeeding growths.

NUTRITIVE VALUE OF TWIGS

Where available feed is plentiful, deer tend to nip the tender tips of twigs se-

lectively, up to about two inches of length, but they take more of the stem where the winter browse is limited in amount. Series of twigs of varying lengths were collected and weighed to learn whether there are differences in the nutritive values of different stem portions from individual plants. The terminal inch was heavier than any other inch length up to the fifth inch, after which the woody portion was heavier; this difference was greater after the twigs had been air dried. Chemical analyses on these twig lengths were made for their content of protein, ash, fat, crude fiber, and carbohydrate (Table 1).

On stems with leaves, the shorter the stem the higher was the content of protein, fat, ash, and carbohydrates and the lower that of crude fiber. On stems without leaves, the tip or bud ends had higher percentages of protein, fats, and carbohydrates; sample no. 1 was higher in ash than in the butt ends of the stem (sample no. 7). Leafy material alone was higher in protein and carbohydrates and lower in crude fiber than the stems, either with or without the leaves. Pound for pound there seems to be more nutrients in the tip ends and leaves than in the rest of the stem.

REMOVAL OF DEER

A guiding principle in determining the necessity for removal of deer is the recommendation of D. I. Rasmussen: one acre of average winter range per deer-month, if undue losses and range depletion are to be avoided. At present, the Schell Creek winter range has about two-thirds of an acre per deer-month during the time the animals are on the range. Assuming equal grazing capacity, about one-third of the present herd should be removed and the remainder then kept at about 1,700 head. In subsequent years the numbers to be removed will be based on the results of the winter sex ratio, spring census, and condition of the winter range. The present program aims first to reduce the herd to the carrying capacity of the range and then to manage it on a sus-

TABLE 1.—CHEMICAL ANALYSES OF PURSHIA TWIGS, CURRENT GROWTH OF 1941.

Sample no.	Percentages					Materials
	Crude protein	Crude fat	Crude fiber	Ash	Nitrogen-free extract	
WITHOUT LEAVES						
1	7.81	6.0	25.3	3.17	57.72	2″ tips of 5″ class
2	6.66	5.2	32.8	2.07	53.27	3″ butts of 5″ class
3	9.23	6.5	20.0	2.59	61.68	2″ tips of 4″ class
4	8.47	6.2	23.6	3.62	57.84	2″ butts of 4″ class
INCLUDING LEAVES						
5	9 37	6.6	19.6	3.40	61.03	1″ class
6	8.40	5.6	26.0	2.32	57.68	4″ class
7	8.38	5.1	28.2	2.43	55.89	7″ class
8	13.09	6.3	11.7	3.44	65.47	leaves

tained yield basis consistent with the available year long food supply.

REGULATION OF DEER POPULATION

In Nevada, control of game is handled mainly by the County Commissioners who set the seasons and bag limits for their respective counties. In the past they usually have acceded to the desires and recommendations of local sportsmen. A recent act of the Nevada Legislature authorizes the Commissioners in any county, upon the application of any person, organization, or governmental department, to appoint a committee of five, one each from sportsmen, livestock interests, the U. S. Forest Service, U. S. Grazing Service, and U. S. Fish and Wildlife Service, to consider the advisability of reducing the deer, antelope, elk, or bighorn sheep in any district or specified portion of such county. Whenever, in the judgment of such a committee, the big game has increased so that a surplus exists or the animals are damaging public or private property or overgrazing their range, the committee shall make appropriate recommendations to the State Fish and Game Commission as to the areas being damaged, extent of damage, and number and kind of game to be removed.

Opposition was manifested by some local sportsmen to killing does and to opening the Schell Creek Game Refuge to hunting, although both measures are needed to save the winter range and prevent loss of deer through starvation. The County Commissioners appointed a committee to investigate and make recommendations for proper management. After examining the area and discussing the author's report, the committee agreed with the latter, and recommended that the herd should be reduced by about 800 head, including 300 does. The committee also recommended opening the refuge to hunting during the 1943 season because the main concentrations were on or near the wintering areas of the refuge. The Commissioners of White Pine County concurred and on petition the Governor opened the refuge to hunting in 1943. Likewise, the State Fish and Game Commission approved the removal of 300 does.

Three checking stations established on roads from the area showed that 380 bucks were legally taken from the area as compared to 213 the previous year. The Commissioners also authorized the taking of 200 does from Duck Creek Valley and 100 from the Spring Valley side. With 300 permits issued, the hunters removed 159 from the Duck Creek area and 33 from the Spring Valley side.

Early in the spring of 1943, 2,009 deer were actually counted on the area; allowing for a 25 per cent increase from the fawn crop, the population should have been about 2,511 when the hunting season opened. The removal of 572 deer reduced the herd to 1,932 head or 70 less than the 1943 spring count. Most of the reduction was made on the Duck Creek area. The net result of the kill on the latter area was to decrease the herd by 181 animals from the 1943 spring count of 1,314 deer. The kill was so small on the Spring Valley side that the 1944 fawn crop actually increased the number of deer present.

Bucks from the Duck Creek area weighed at the checking station averaged 133 pounds in 1942 and 122

pounds in 1943. The 131 does taken and weighed in 1943 averaged 77.7 pounds, considerably below weights in good range country. Both does and bucks were light in weight indicating that there are too many deer for the present productiveness of the range.

RESULTS OF 1943 HUNT

Shortage of ammunition and restrictions on gasoline and automobile tires did not prevent hunters from participating, since fully 200 more licenses were sold in White Pine County in 1943 than in any previous year, and the legal kill of deer was larger than in 1941 and 1942. On the entire Schell Creek Division, the 1944 census showed more deer than recorded in 1943, despite heavy removal from the Duck Creek area.

DUCK CREEK UNIT

Following the 1943 hunting season, a sex count in December of 294 deer in the Duck Creek area showed 1 buck to 2.6 does; in 1942 the ratio was 1:1.56. Removing 159 does in 1943 thus affected sex ratio, but plenty of bucks remained to ensure a satisfactory breeding potential. The 1943 spring census listed 1,314 deer; a summer fawn crop of 25 per cent would raise the number to 1,642 animals. During the 1943 autumn hunting season, 509 deer (350 bucks, 159 does) were taken—the legal removal exceeded the theoretical increase by 181. In the spring count of 1944 there should have been 1,133 recorded, if the same proportion of deer were seen in both years. The 1944 census was made when conditions as to weather, snow, and vegetation approximated those of 1943; the count was 1,143, or 10 more than expected. Since the winter range normally will not adequately support more than about 1,000 deer, further reductions obviously are needed.

SPRING VALLEY UNIT

There were 695 deer counted in the spring of 1943 under ideal conditions. This area, being less accessible, was hunted lightly and the legal kill was only 30 bucks and 33 does. The fawn increase (25 per cent) should have been about 175 head, making a total of 870, from which 63 were removed by hunting; with no natural losses this would leave 807 for the 1944 census. The latter showed 1,148 by actual count. The noticeable increase in the census figures can be ascribed to the considerably greater depth of snow in the mountains immediately above the winter range during the spring count of 1944; more deer were forced onto the lower foothill country where they could be counted easily and more completely.

This unit, of about 3,500 acres, has less winter range than the Duck Creek area and obviously is stocked to twice its capacity. The deer should be drastically reduced and held to about 700 in number. In 1944, for the first time, there was a distinct highline on the pinon pines due to deer browsing. When deer are forced to eat the needles from the pinon pines during the winter and spring months, it is good indication that the range is far depleted and that losses through starvation will result in time.

SUMMARY AND CONCLUSIONS

1. Several regulatory practices have had a cumulative effect in the sporadic and rapid build-up of mule deer over

much of the western United States.

2. The U. S. Forest Service and U. S. Fish and Wildlife Service by factual study are seeking to demonstrate the possibilities in management of deer on overpopulated and deteriorating ranges to correct these errors.

3. Sample studies have been made on the Duck Creek area in the Schell Creek Division of the Nevada National Forest where the amount of winter range is the limiting factor.

4. This is one of the few areas occupied by mule deer in which damage to the range was discovered in time to take remedial measures before a critical stage was reached. By such action, it was possible to bring about a proper relation between the number of deer and the proper carrying capacity of the range. Where deer and the range they occupy get out of balance because corrective management measures are not taken in time, both the deer and the range suffer heavy losses.

5. In the area studied, instead of one acre of winter range per deer-month, there was but two-thirds of an acre available, an amount inadequate for the deer.

6. The local yearly census should be made immediately after the snow has disappeared from the flats on the winter range and the first green grass has appeared. Sex ratio counts should be made before any bucks have shed their antlers and should be based on at least 500 animals.

7. Measurements of twig lengths to determine utilization of browse species before the deer enter the winter range are made (usually in December) and again just after the animals leave for the summer range.

8. Chemical analyses of twig ends of browse plants show the most nutrients in the leaves and bud ends. On ranges not overutilized, the deer selectively nip off only the tips or tender portions of stems, but on overgrazed ranges they consume practically all of the current growth and sometimes much of that of the previous year.

9. Management practices should be based on: (a) the deer population in relation to acreage of winter range; (b) the winter and spring condition of the animals; (c) the winter sex ratio; and (d) the degree of browse utilization.

10. The first year's removal of deer from the Duck Creek area, after being opened to hunting of both bucks and does, reduced the herd by approximately 170 animals. The present herd should be reduced to about 1,000 head.

11. The deer on the Spring Valley side have increased to numbers far in excess of proper carrying capacity for the limited winter range and should be reduced to about 700 head.

AGE DETERMINATION IN THE RING-NECKED PHEASANT

Joseph P. Linduska
U. S. Bureau of Entomology and Plant Quarantine,
Box 3391, Orlando, Florida

The Game Division of the Michigan Department of Conservation has in progress an intensive, long term ecological study of farm wildlife at the Rose Lake Wildlife Experiment Station in Clinton and Shiawassee counties. Included are kill records for several species of small game during a five year period. These emphasize the necessity of knowing the age composition of populations before any valid interpretation of changing population levels can be made. The need for simplified means to obtain such age ratios is apparent. Evaluation of known methods for age determination and attempts to develop new methods have consequently been important in the research program. Close supervision of the autumn harvest (October 15–November 5) and checking all game through a central laboratory have made possible a leisurely examination of significant numbers of animals.

For the ring-necked pheasant (*Phasianus colchicus torquatus*), the bursa method of age determination (Gower, 1939) has furnished an accurate standard against which other methods giving promise of greater simplicity and adaptability could be checked. In the autumn of 1940, the age of 177 cocks was so determined. The differential molt of old and young pheasants and the length and appearance of spurs were checked for reliability as age indicators. A simplified method for external determination of the presence of the bursa was also developed in that year (Linduska, 1943). In 1941 the ages of 245 males were established by reference to the bursa, and various spur characteristics were recorded. In 1942 and 1943, 207 and 120 cock pheasants, respectively, were killed and examined in the laboratory. In 1942, the age of males was determined by testing the strength of the lower mandible and noting the appearance of the spurs. These determinations were checked for accuracy in each instance by examination of the bursa. On the basis of information obtained during the previous three years, practically all males taken in the 1943 season were assigned to age groups by inspection of the plumage and spurs, and by testing the strength of the lower mandible. Questionable individuals were examined for the presence or absence of the bursa.

Many members of the station staff assisted in compiling the data from which the following observations have been drawn, particularly Durward L. Allen, Biologist in Charge.

Plumage

In southern Michigan, the number of juvenile birds attaining full adult plumage by mid-October varies from year to year, depending apparently on the lateness of the nesting season and the extent of renesting. The number of cocks still recognizable by plumage as juveniles, however, is too small for this character to be of appreciable value when used alone. In 1941 practically all cocks of the year were in full adult

plumage by hunting season. The greatest number retaining sufficient juvenile plumage to permit age recognition was found in 1943 when 12 of 90 juveniles could be so detected.

The observation that the post-juvenal molt of cock pheasants of the year ordinarily is completed later than the post-nuptial molt of old cocks (Bent, 1932) was investigated and found to have but slight application in the recognition of individuals of the two age groups for the period covered by the pheasant hunting season in Michigan. The tail feathers, which are among the last to complete growth, were selected as indicators of completion of molt and were examined on birds killed in 1940. A grey sheath indicative of continuing growth was present around the base of the central tail feathers in 108 of 109 juvenile males killed in the autumn of that year. Among adults, completion of the molt, as indicated by the absence of growing feathers in the tail, was observed in only four of 10 birds. From these observations it would appear that completion of the molt in males constitutes good evidence of adulthood, but the percentage of adults showing completed regrowth of plumage is too small for the character to have any practical application. Growing tail feathers were noted in practically all autumn shot juveniles, but the information was of no real utility since a similar condition was observed in over half of the adults. Petrides (1942) found no reliable method for distinguishing young and old pheasants by plumage characters.

CONDITION OF SPURS

Measurements of spurs from autumn shot male pheasants in 1940 and 1941 showed a statistically significant difference in spur length between young and old birds. Moreover, other characteristic differences in color, shape, and texture of the spurs became obvious with the handling of a series of individuals of the two age groups and offered important means for age recognition (Linduska, 1943).

STRENGTH OF LOWER MANDIBLE

A basis for objective means to determine the age of some birds is provided by the considerable differences in extent of ossification of skull structures. A rough measurement of the relative strength of the lower mandible in young and old pheasants was made on males shot during hunting seasons of 1942 and 1943. This involves lifting the bird by the lower mandible. It has been used by European workers on the red grouse (*Lagopus scoticus*) of the British Isles (Committee of Inquiry on Grouse Disease, 1911), on the Hungarian partridge (*Perdix perdix*) and red quail (*Alectoris rufa*) in France (Bureau 1911, 1913, quoted by Petrides 1942), and in the United States on the sage grouse (*Centrocercus urophasianus*) by Girard (1937). A surprising measure of accuracy was indicated when used on 313 male ring-necked pheasants. The lower jaw of an adult male proved strong enough to support the weight of the body, even when the animal was jarred and the mandible rotated while so held. In juvenile birds the lower jaw usually was too soft even to permit lifting the bird and always yielded with a slight shaking of the carcass. In 1942 the test was applied to 18 adult and 175 juvenile males, also examined for presence of the bursa. The lifting method agreed with results obtained by bursa examination

for all of the juveniles and failed with only one adult.

Because of the high measure of reliability previously shown for the "jaw" and "spur" methods of determining age, the jaw test was confirmed by bursa examination during the 1943 hunting season only in those few instances where there was disagreement with the estimated age as indicated by spur examination. Among 90 juveniles, there was a question of age in only three. Two were judged to be adult by the appearance of the spurs, but the mandible of each indicated juvenility by yielding when tested. Reference to the bursa revealed that they were juveniles. The third was judged to be a young of the year by the spurs, but gave a conflicting result when tested by the mandible; a bursa was present. The spur and jaw tests agreed in 29 of 30 adults; one had juvenile spurs but the lower mandible supported the body weight, and there was no bursa.

SUMMARY

During 1940 to 1943, over 700 male ring-necked pheasants were harvested from the controlled hunting area at Rose Lake, Michigan, and were examined in the station laboratory. Over 1300 others were given cursory examination at conservation officers' road blockades and 300 live individuals (live-trapped or on game farms) were examined. These studies showed that: (1) probing the bursa from without is a practical and reliable method for distinguishing adults from young of the year, in either living or dead individuals, until as late as December; (2) the "strength of lower mandible test" is an objective method of high accuracy useful in conjunction with spur examinations to determine the age of practically all autumn cocks, and this combination, because of simplicity and speed, probably will be most useful in age analysis of shot birds on controlled hunting areas and in other situations where rapid determination is necessary; and (3) plumage differences between adults and young cock pheasants provide means for distinguishing a few autumn individuals, but too few of the young retain sufficient juvenile plumage into that season for the character to be of any consequence when used alone.

LITERATURE CITED

BENT, A. C. 1932. Life histories of North American gallinaceous birds. U. S. Nation. Mus. Bul., **162**: xi+490 pp., 93 pls.

BUREAU, LOUIS. 1911. L'age des perdrix: I. La perdrix grise. Soc. Sci. Nat. Ouest France (Nantes), Bul., ser. 3, 1(1-2): 124 pp., 35 figs.

1933. L'age des perdrix: II. La perdrix rouge. Soc. Sci. Nat. Ouest France (Nantes) Bul., ser. 3, 3(2): 143 pp., 53 figs.

COMMITTEE OF INQUIRY ON GROUSE DISEASE. 1911. The grouse in health and disease. London, Smith, Elder and Co., 1: xxiii+512 pp., 59 pls., 31 figs.

GIRARD, G. L. 1937. Life history, habits and food of the sage grouse. Univ. of Wyoming Science Publ., 3(1): 1–56.

GOWER, W. C. 1939. The use of the bursa of Fabricius as an indication of age in game birds. N. Amer. Wildl. Conf., Trans., 4: 426–430.

LINDUSKA, J. P. 1943. A gross study of the bursa of Fabricius and cock spurs as age indicators in the ringnecked pheasant. Auk, **60**: 426–437.

PETRIDES, G. A. 1942. Age determination in American gallinaceous game birds. N. Amer. Wildl. Conf., Trans., 7: 308–328.

BRIEFER ARTICLES

NON-BREEDING IN BIGHORN SHEEP

Mammalogists have long admitted that something was wrong with our mountain sheep. Federal Aid sheep projects have brought varying results in several states. Written records ascribe the trouble to several logical factors, including poor food conditions due to competition with domestic animals and game, serious predation, disease, extermination through over shooting, possible inbreeding after heavy reduction, and similar simple things that are understandable but difficult to remedy. Some of my observations on the Desert Game Range in southern Nevada since June, 1942, may be of interest to other biologists as hypotheses applying to sheep problems elsewhere.

In the best sheep habitat of the Desert Game Range, the stocking of sheep was far better than I had hoped. The 1942 lamb crop was fair and in 1943 it was better. Under the present population of mountain sheep and current stocking with domestic animals, there is no livestock competition and there are no domestic sheep or goats present. Food conditions seem to be ideal, and the little water needed by *Ovis canadensis nelsoni* is certainly adequate. Recommendations for extensive improvements have been made against the time when the sheep herd doubles. There is no game competition in the area, only a few mule deer being present. In other parts of the Range, however, there are many deer and a few elk. It is definitely a part of the plan to keep other game in the Sheep Mountains down to token numbers. There is little evidence of disease. Illegal shooting is apparently so slight as to have no effect. There is predation by an occasional wandering mountain lion, but this plus the coyotes and wildcats show no evidence of seriously reducing the sheep herd. After having investigated sheep problems elsewhere, I thought that the Sheep Mountains range, where the sheep concentrate around some 30 widely dispersed springs during the summer watering season, was so ideal that an open season would be needed in a few years to keep down the population.

In 1944, however, there was a very poor lamb crop. Ordinarily breeding takes place early in the autumn and lambs are born in February and March; February is supposed to be the important lambing month. I have been present through only one lambing period and only a few lambs were born then, so my evidence is limited. In 1944, I did not find a lamb until March 16; the first seen was large, with well-developed horns, and certainly a month old. After the time when all lambs ordinarily would have been born, I saw bands of up to 24 ewes with only a single lamb and frequently saw a dozen ewes without a lamb. The possibility that the lambs might have been hidden was carefully considered. The best record was on April 22 when I saw 14 lambs with 57 ewes; these varied from little gray fellows not over a week old, to February lambs with horns perhaps 3 inches long. At times there were bunches of ewes with lambs showing a normal to ideal ratio. One group comprised 5 lambs to 7 ewes and another 5 lambs to 6 ewes, but such groups were rare. The last very young lamb was seen on June 4 when, unfortunately, I had no binoculars, but saw about 40 sheep and lambs where I did not expect them. Some were so far away that naked eye information was not reliable, but the one lamb was close by and very young, obviously born after May 1.

The area is vast, help is scarce, and observations are sketchy, but the 1944 lamb crop unquestionably was very small as compared to that of the two preceding years and was also more variable in age, indicating a widely spread breeding season. Observations during the preceding autumn corroborated this long season, but breeding observations alone are inconclusive. Other observers in other places report more definite breeding seasons.

After considering all possible factors, I feel sure that the majority of the mature ewes did not produce lambs. As a possible hypothesis, I think that there may have been temporary sterility on the Sheep Range as a result of the ewes being over bred by too many rams. The number of rams equals or exceeds that of the ewes. This over breeding theory of sterility may have been published

first by Wm. M. Rush ("Wild Animals of the Rockies," Harper Bros., Chapter XXX, 1942) or in a preceding article in *Outdoor Life* called "Bighorn need a break." It is a definite belief by practical observers. It may be serious only in years when the weather or the food as affected by weather spreads the breeding season over a long period. If all ewes come into heat and become pregnant in a comparatively short time, a 1:1 sex ratio will do little harm. But if only 5 per cent of the ewes are in heat at one time and a half dozen or more rams stay around one ewe—as they do—then move on to another after the first ewe is definitely overworked, the chance of sterility from over breeding is certainly a possibility. Weather observations at headquarters of the Desert Game Range, some 5 miles from the bases of the Sheep Mountains, are fairly complete but there is only slight information about conditions on the mountains; it would take a long time to determine what weather conditions, if any, constituted the exact cause of a widely spread breeding season. Even if known, there is little that can be done.

There has been no open season on these sheep for many years. If there are so many rams as to cut down breeding under certain conditions, a reduction of rams to a sex ratio of 25 rams to 75 ewes or even lower might improve the herd. One breeding ram to 3 ewes should be plenty for a polygamous ruminant; and mountain sheep, like their domestic relatives, are decidedly polygamous.

There is as yet no proof for the theory set forth here; it is put on record solely in the hope that other observers may search for or think of something to throw light on the sheep problem. I am convinced that periodical non-breeding or more correctly non-lambing is the reason why local bighorns do not reach a saturated population. The same condition may prevail in other states and with other subspecies of sheep.—ALBERT VAN S. PULLING, *U. S. Fish and Wildlife Service, P. O. Box 432, Las Vegas, Nevada.*

FIELD RODENT CONTROL BY DESTRUCTION OF BURROWS

Efforts at control of rodents injurious to agriculture in the western United States began soon after the "Gold Rush" and have increased in both extent and intensity until huge sums now are expended annually. Despite the magnitude of these operations, the recorded knowledge on the basic natural history of these animals, such as should underlie such operations, is imperfect and often meager. It is based mainly on relatively few local studies, often by naturalists not particularly interested in the economic aspects. There have been many trial-and-error experiments with poison baits and gases by state and federal officials, but these commonly lack adequate controls, rarely if ever are subjected to statistical analysis for validity, and usually appear only in mimeograph reports of limited distribution. There is great need for more basic knowledge of rodent biology and for new approaches to the problems of control. The ground squirrels, prairie dogs, pocket gophers, mice, and jackrabbits are the most important field rodents from an economic viewpoint.

On some limited areas it has been possible by strenuous and continuing operations to reduce ground squirrels to small numbers (reportedly 1 or 2 per 10 acres in a few cases) and pocket gophers have been almost eliminated on occasional ranches. In most places, however, the reduction is only moderate and their numbers are held down only by work year after year.

Pocket gophers and ground squirrels excavate and live in underground tunnels of varying size (Storer, Univ. Calif. Agri. Ext. Circ. 79, rev., 1942). Typically a gopher burrow system is inhabited only by one individual at a time, but after the inhabitant has been killed or removed, the system remains and often receives another tenant in time. Of ground squirrel burrows, the smaller and shorter types usually harbor one or two individuals except for the annual brood which later is dispersed to other sites. There are also larger "colonial" burrows with several openings and nests and several hundred feet of tunnel, and these may accommodate 7 or 8 squirrels at one time.

The burrows of gophers and squirrels are at various depths but commonly below the

reach of an ordinary plow; in firm soil they are not soon collapsed by the penetration of winter rains or even of irrigation water under either field or garden conditions. Once the current tenant(s) is killed by natural enemies or disease or by control operations, its housing is left free and in condition for the next individual of its kind. (Burrowing owls, cottontails and skunks often use squirrel burrows, as do gopher snakes and rattlesnakes as well.) In the great acreages of the arid West, however, vast numbers of "rodent housing units" are constantly being vacated and reinhabited by pocket gophers and ground squirrels. Often the existing burrows require little or no reconstruction, and consequently there is scant surface indication of reoccupancy until damage to nearby plants reveals the presence of new tenants.

We know that some habitations for human beings are more desirable and more sought after than others, and the same situation evidently obtains among these rodents. Certain burrows or burrow systems are inhabited, continuously or intermittently, through long periods. The home gardener often experiences repeated invasions of his plot by pocket gophers which often enter through established tunnels from adjacent lands. Some favorable sites for ground squirrels have been occupied for years, probably by successive generations. Removal of the tenants, by either natural or artificial means, is soon followed by reoccupancy.

It is an established axiom of animal ecology that a species is rendered more secure by an abundance of suitable cover or shelter—for escape from enemies or the elements, and for brood production. Existing programs and methods for control of gophers and ground squirrels include no measures designed to reduce the "quarters" available to them, although in rat control it is well known that successful efforts must include effective reduction of "rat harbor," besides the usual trapping, poisoning, and gassing. In similar manner, it should be possible to increase somewhat the effectiveness of control operations against pocket gophers and ground squirrels by partial or complete destruction of the established burrows to which these animals resort.

For pocket gophers use of a chisel or subsoil plow reaching down 12 to 18 inches would destroy a large percentage of the existing tunnels that parallel the surface at depths of 7 to 12 inches in the ground. This would be economically practicable only on the more valuable lands such as those used for commercial truck gardens and seed fields yielding crops of high value per acre and could not safely be used in orchards because of injury to the superficial roots of the trees. Such treatment might not be needed annually but only at longer intervals and when the incursion of gophers not killed by other control measures results in a population harmful to the crop.

The burrows of ground squirrels commonly penetrate to depths of several feet and many are in roadside embankments or on hills. Collapse of at least the more superficial portions, to a depth of 24 to 36 inches, by the use of explosives would be practicable save where the tunnels extend into rockpiles, under fences, bridges or culverts, or beneath large and valuable trees. After the termination of the war, there will be excess stocks of explosives. In the hands of former military personnel already familiar with the handling of explosives and easily trained in the proper methods for destruction of burrows, a useful conversion of material and manpower could be made by this means to the vexing problem of squirrel control. Experimental studies will be needed to determine the most suitable methods, types of explosives, and charges needed in various types of soils and under differing conditions of soil moisture. The minimum charges to effect collapse of burrows without cratering the land surface or overturning the superficial layers of soil also would have to be learned, and the economic value of the practice would have to be ascertained.—TRACY I. STORER, *Division of Zoology, University of California, Davis, California.*

NEWS NOTES

There has been expanding use of the organic chemical DDT for the control of insects bringing sickness and discomfort among our armed forces. Results have been so successful that there is wide interest in its possible use for control of other insects, particularly those of crops and forests.

There is little or no information as to what harm might accrue to wildlife should DDT be applied on a large scale, but plans have been made to study this problem.

This year the U. S. Bureau of Entomology and Plant Quarantine will apply DDT to several forest areas, chiefly in the northeastern states, and the U. S. Fish and Wildlife Service will study these areas to determine the direct and indirect effects on vertebrate wildlife. The entomologists will consider effects on the insect fauna as a whole.

Preliminary studies suggest that few birds and mammals, if any, are killed by DDT, but indirect harm may directly result through reduction of insect-food supplies, especially when applications are made shortly before or during the nesting season. DDT is relatively stable and insoluble in water. In forests, a single low concentration application (in oil) has continued to kill insects for prolonged periods as they come in contact with the minute crystals left after the solvent has evaporated. A sustained reduction in the total insect population thus results. Applications of DDT by aircraft at 5 pounds per acre have killed amphibians and fishes either directly or through their taking poisoned food. The effect on these groups at different rates of application will be investigated under various field conditions.

Experiments to determine levels of chronic and acute poisoning from DDT taken internally by small rodents, rabbits, bobwhites, mallards, fish and other cold-blooded vertebrates, are already in progress by the Fish and Wildlife Service.

The results of such field and laboratory studies will indicate whether use of DDT for pest insects is hazardous to wildlife and will guide the entomologists in developing formulas, dosages, and methods of application that avoid hazards to beneficial wildlife.

A convenient cross section of the work and thinking and planning by officials of the several federal agencies in the wildlife field is provided by the "Hearings before the Select Committee on Conservation of Wildlife Resources," House of Representatives, 78th Congress, 2d Session, November 17, 27–29, 1944 (Washington, Govt. Printing Office, 500 pp., 1945). The hearings comprise extensive semi-formal reports and discussions by leaders in the respective services and bureaus, including I. N. Gabrielson and F. C. Lincoln, Fish and Wildlife Service; V. H. Cahalane, National Park Service; L. W. Swift, Forest Service; E. H. Graham, Soil Conservation Service; W. E. Warne, Bureau of Reclamation; G. R. Goethals, War Department; and Mr. Ryan, Grazing Service.

The formal statements often are lengthy and they contain much tabular material not readily available elsewhere. These are followed by series of questions put by members of the Congressional committee and answered by the "witnesses." Despite some public opinion to the contrary, the reader is impressed with the serious efforts made by committee members to understand the problems in this field. As a whole, this "volume" brings forcibly to attention the many varied, complex, and interlocking problems involved in economic vertebrate zoology in the United States and the great strides which have been made in dealing with them during recent years.

At several places in the hearings consideration was given to duplications of effort by the several agencies. The magnitude of the areas and subjects covered and the quasi-political background upon which any federal efforts rest of necessity make an "ideal" administration difficult or impossible to achieve. It seems evident, however, that our "public servants" in conservation are endeavoring to perform their work in ways helpful to the general cause.

Appended to the hearings is a series of reports (pp. 377–500) from state fish and game departments, sent in response to a memorandum from Chairman A. Willis Robertson of the select committee asking about work in the states on game and fish, particularly on projects using Pittman-

Robertson funds. The varied form, content, and size of these reports (not all states replied), all in response to a uniform request, provided a convincing demonstration of some reasons for difficulty in wildlife management. The answers variously reviewed current activities, outlined postwar plans, reported faithfully on Pittman-Robertson work, or presented unessential and sometimes irrelevant details.—T.I.S.

Conservationists in the United States interested in problems relating to national parks and monuments and nature reservations should read the recent comprehensive report on "Nature Conservation and Nature Reserves" in the British Isles (Journal of Animal Ecology, 13: 1–25, 1944 [=1945]; also Journal of Ecology, 32: 45–82, 1944). Since 1941 committees and conferences on nature preservation in Britain have been considering matters in this field, particularly those relating to post-war reconstruction. The report summarizes the objectives to be sought, the faunal and floral components requiring attention, the methods and machinery of nature conservation, and the needs for an educational campaign and for establishing a national wildlife service. Lands that have been lived upon for over two thousand years by mankind in progressively differing stages of civilization offer problems quite different from those in the New World where there still are vast areas of "wild" land, much in government ownership. The British suggestions for a conservation program fitted to areas that are densely populated and intensively utilized may be of particular profit to persons in this country dealing with the adjustments necessary in the older and more thickly settled portions of North America.—T.I.S.

OBITUARY

Wilbur Stuart Long

Wilbur Stuart Long, a member of the American Society of Mammalogists, The Wildlife Society, American Ornithologists' Union, Cooper Ornithological Club and Wilson Ornithological Club, was born July 11, 1903, at McArthur, Ohio, and died at Moab, Utah, October 19, 1944.

In 1935 he received his M.A. degree at the University of Kansas and entered the U. S. National Park Service as wildlife technician in Zion National Park, Utah. In August 1936 he transferred to the Soil Conservation Service as junior biologist and in January 1939 was promoted to assistant biologist. At the time of his death he was district conservationist for Grand and San Juan counties, Utah. While with the Soil Conservation Service he worked in Colorado and Utah.

His chief interest was ornithology and he was a born collector and fieldman. He collected birds in several western states and published several articles on ornithology.—A. E. Borell.